Regional Review Report

Water Future Vision and Cooperation for Sustainability in Turkic States

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Regional Review Report *(Preliminary version)*
Water Future Vision and Cooperation for Sustainability in Turkic States

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PREFACE

One of the most demanding issues of the 21st century is the effective management and allocation of increasingly scarce water resources. Water is essential for satisfying basic human needs, fostering social and economic development, and conserving ecosystems.

The ongoing water crisis at local, national, and global levels stems from a rapidly growing population, changing levels of economic development, poor water management and allocation practices, inequitable access to scarce surface and groundwater resources, and the impacts of climate change.

In many regions, particularly in the Turkic region, water security is a crucial issue that must be considered when developing sustainable policies for water resource management. The Turkic region remains vulnerable to natural disasters and the adverse consequences of climate change.

The Aral Sea disaster has severely impacted the ecological system in Central Asia, becoming a significant global issue. Meanwhile, the continuous decline in the water level of the Caspian Sea further complicates the region's environmental situation.

Only through close cooperation between states and international organizations, both regionally and globally, can we achieve the desired results. The Organization of Turkic States (OTS) is committed to fostering collaboration and strengthening unity and resilience within the Turkic World, thus contributing to regional and global stability and prosperity.

Among our Member States, Kyrgyzstan possesses abundant resources of both ground and surface waters, including substantial reserves in rivers, ice, and snow tracts. These water resources are part of our shared natural heritage, and it is imperative that we use them wisely. The agreement between Kazakhstan, Kyrgyzstan, and Uzbekistan to construct the Kambarata-1 Hydropower Plant (HPP) on the Naryn River in Kyrgyzstan is a critical step toward providing green energy and ensuring sustainable water use in the region.

I am proud to say that, in cooperation with the Drought Prevention Institute of the OTS in Budapest, we have already embarked on favorable projects aimed at addressing water-related challenges.

This report, prepared by the Turkic Academy, provides an in-depth analysis of the existing water resources in the Turkic States, water scarcity levels, sectoral water allocation, and other relevant issues.

I believe that this study is an invaluable resource for developing appropriate measures to address current environmental challenges, particularly water security issues, in the Turkic countries.

I extend my deep appreciation to the team at the Turkic Academy, along with the researchers, specialists, and experts from the Member States and others who contributed to this vital work.

Amb. Kubanychbek Omuraliev
Secretary General of the Organization of Turkic States

FOREWORD

I am honored to present this comprehensive report on the Water Future Vision and Cooperation for Sustainability in Turkic States, which outlines the current state of water resources and offers strategic recommendations for fostering cooperation among the Turkic states.

Water scarcity is a pressing issue affecting numerous nations worldwide. Over 1 billion people experience some form of water scarcity daily. Furthermore, it is projected that the lack of freshwater will pose an increasingly devastating threat to humanity in the 21^{st} century. By 2050, at least one in four individuals is expected to reside in a country where freshwater shortages are chronic.

The trends of population growth, rapid urbanization, and increasingly water-intensive development patterns, coupled with rising living standards, present significant challenges to freshwater security also in many Turkic states. These factors are exacerbated by climate change, which leads to rising temperatures, erratic rainfall patterns, and extended periods of drought. The consequences of these issues pose significant threats to human health, food and energy production, industrial operations, national economic stability, and the survival of diverse animal species, plants, and natural ecosystems.

In this critical context, the urgency for collaborative efforts and effective transboundary water cooperation among Turkic states to safeguard and optimize shared water resources is more pressing than ever.

Integrated water resources management is essential for ensuring equitable access to water resources and services across all communities, sectors, and uses. This approach promotes sustainable water conservation practices and safeguards water resources from pollution. Effective water governance must facilitate the participation of all relevant public and private stakeholders in decision-making processes by examining best practices and incorporating lessons learned. Additionally, a crosssectoral approach is crucial for enhancing coordination among sectoral strategies and integrated planning, which links water management with agricultural, energy, and other pertinent policies.

A crucial element of effective water management is comprehensive data collection. Accurate knowledge of water consumption volumes in each region is essential for implementing sound management practices and improving water efficiency, particularly in the agricultural sector. Without precise data, allocating resources efficiently and ensuring sustainable usage becomes challenging. This report provides valuable data and insights into water resource sustainability in the Turkic states, offering context to understand the current status of water resource management and the policies implemented to address water-related challenges. Additionally, it presents recommendations for both joint and individual actions.

The findings of this report underscore the critical need for innovative strategies to effectively manage and conserve water resources, protect ecosystems, and enable Turkic states to adapt to the challenges posed by climate change. By leveraging shared knowledge, expertise, and resources, Turkic states can implement sustainable water management practices that will bolster the resilience of their economies.

One of the key advantages of this report is its comparability among Turkic states, enabling governments to assess the effectiveness of their water resource sustainability policies and learn from best practices. Furthermore, the comprehensive range of issues addressed in the report makes it a valuable resource for tackling water-related sustainable development challenges.

This report was developed with the dedication, skills, and efforts of many scholars, to whom I extend my heartfelt gratitude. I hope that this report will inform policymakers, the media, and the general public in Turkic states, stimulating a rich dialogue on the current and future pathways to sustainable water management.

Prof. Dr. Shahin Mustafayev
President of the Turkic Academy

INTRODUCTION

The members of the Organization of Turkic States (OTS) have its own history of social-economic development and water sector governance practices. In the past Azerbaijan, Kazakhstan, Kyrgyzstan, Turkmenistan and Uzbekistan were part of the former Soviet Union with the commonly applied planned economy and water management structure. Currently these countries continue their cooperation as a member of Commonwealth of Independence Countries and within different regional formats.

After gaining independence in 1991, all these countries started transition process to the market economy and currently the process is going on in consideration with their own experiences and national peculiarities in each country. In general, since Azerbaijan, Kazakhstan and Turkmenistan prioritize the production and export of hydrocarbon resources, cotton production plays a significant role in Uzbekistan's exports, the economy of the country also relies on agriculture, natural gas, and minerals. Agriculture, tourism, and manufacturing are developing sectors and gradually playing important role for economic diversification in Azerbaijan. Kazakhstan's economy is the largest in Central Asia and is characterized by its rich natural resources, oil, gas, and mineral export is important for the country, and agriculture, manufacturing, tourism and IT sectors are under development, contributing to the country's economic diversification. The economy of Kyrgyzstan is diverse, due to agriculture and gold mining, the country has the potential to produce hydroelectric power, and electricity exports to Kazakhstan and Uzbekistan are increasing year after year. Though Turkmenistan has significant natural gas exports, cotton and textile are also key sectors for the country economy. Türkiye is the more developed country among the member states and in the Near East, has fully oriented and established market economy with a strong industrial, processing sectors, significant agricultural production and agrifood export to the different countries.

The geographic location and on-going climate changes in the OTS member countries requires to pay more attention to the water resource management and ecological safety of the water use.

The future development of member countries economy depends on also how they can develop climate resilience policies and implement comprehensive measures and effective programs for sustainable development of the country in the face of the challenges posed by ongoing climate change.

Azerbaijan faces challenges with water scarcity, particularly in its arid and semi-arid regions. The country's economic activities, including agriculture require substantial water resources. The water scarcity situation has far-reaching repercussions, hurting not just agricultural production and food security, but also threatening ecosystems and biodiversity (Ismayılov & Suleymanov,2024). The Kura and Aras rivers are main rivers and vital for the country's water resources, water which it shares with another riparian countries. Kazakhstan is dependent on the water from the Irtysh, Ili, and Syr Darya rivers. Water scarcity is a significant issue, exacerbated by the shrinking of the Aral Sea, which has had severe environmental and economic impacts. The country's agriculture requires substantial water resources (Ozenbayeva, et al., 2022). Kyrgyzstan has abundant freshwater resources due to its mountainous terrain, which is crucial for its agriculture and hydropower generation (Liang et al., 2021). Managing these resources efficiently is key issue to promote national economic development and rational water use by all riparian countries with the consideration of the ecological requirements. Türkiye has a limited water potential per capita of approximately 1300 m^3, and therefore should be considered a water-stressed country with high vulnerability (Melikoglu, 2023). Major rivers like the Euphrates and Tigris are crucial for agriculture and industry. Water management is essential for balancing the needs of its growing population and various economic sectors. Uzbekistan relies on the Amu Darya and Syr Darya rivers for irrigation and agriculture. The country faces severe water scarcity issues due to overuse of river water, especially affecting the Aral Sea basin. The impacts of decreased amount of water levels in major rivers directly affect the water availability to the agricultural purposes (Chathuranika et al., 2022). Sustainable water management is critical for its agriculture-based economy. Turkmenistan faces significant challenges regarding water resources due to its geographic and climatic conditions. The primary sources of water for irrigation are the Amu Darya and Murgab rivers. Efficient management of these water sources is critical for sustaining agricultural productivity (Mayar, et al., 2024).

All member countries currently suffer from water resources reduction and worsening of their quality. Therefore, to cooperate, take joint actions and implement targeted policies, update and exchange of information on the realizing national programs for sustainable use and protection of the water resources is useful, to support, overcome and address the water sector related challenges jointly in member states. This aim is in line with the Turkic World Vision 2040, one of which goal is to develop a framework for achieving the Sustainable Development Goals (SDGs) in member states (UN, 2024), including sustainable and environmentally friendly economic growth, agriculture, rural development, improved social conditions and well-being (Musabay Baki, 2022).

Under the situation of climate change and reduction of water resources, each country defines its own priorities and elaborates water policies at national level, making proposals for more deep cooperation at the regional level to overcome their consequences. These measures shall include the development of appropriate priorities, regional programs to strengthen targeted cooperation, support for the exchange of best practices and the implementation of mutually beneficial regional programs. Since the water resources availability, use, quality and management and are important for the member countries, the development of the accurate key water indicators, digital data system is recommendable, which allows to understand clearly the current state, trends and needs for elaboration of the urgent integrated actions at national level and at regional scale.

I. COUNTRY VICE WATER MANAGEMENT BRIEF ANALYSES

There are similar and different aspects of the situation in water management and water use in the OTS member countries. In this regard, the current situation, the measures implemented and planned in the member countries, and their own water policies are based, first, on clearly recognized national priorities. However, the smooth implementation of national water policy encourages each country to cooperate with neighboring countries on a regional and international platform, considering their geographical location, the location of water resources and the places where they originate. This is especially true for the consequences of climate change, which affects not only an individual country, but almost all countries in the region. From this point of view, issues of optimizing the use of water resources at the national and regional levels are directly and continuously on the agenda.

In Azerbaijan, water resource scarcity and water use efficiency issue are at the center of the government attention. The main predominated condition is that, about 70% of water resources depends on the transboundary flows and current national policy and strategy measures prioritized to increase water resources by the construction of the new water dams on the internal mountain rivers, rational use of water resources in agriculture by application of the modern irrigation systems and minimization of the unproductive losses by elimination of the traditional irrigation practices. The technological water losses originated from the fact that most of the irrigation canals are earth canal systems. Due to the close location of the mineralized ground water table, the soil water-salt balance is controlled by the installation of the drainage systems, covering 610.7x103 ha reclaimed lands. Water losses in transportation is about 30% from the total water intake. Under the condition of the climate change, it is estimated that 15% decrease of the water resources in the country (Rzayev, 2023). According to the prognosis, by 2100, river flows in the country is expected to fall by approximately 26–35%. Water shortages will be more severe in the arid regions of the country and could reduce crop yields (WB & ADB, 2021). Therefore, serious actions have been taking in the country to increase resistance against the concern climatic challenges. High ranking *Water Commission* established in 2020, which in fact plays as a main regulator of the water sector and *Action Plan*, covering urgent measures has been adopted and currently is under implementation. The country has adopted new National Water Strategy on late 2024 which defines key policy, legal, managerial and prioritized investment measures covering *the period from 2024 to 2040*, sets out a three-phase plan.

The first phase (2024-2027) focuses on the modernization of water infrastructure and management, the reassessment and expansion of water resources, and the integrated management of water in the Karabakh and Eastern Zangezur economic regions. During this phase, projects will be implemented to improve the quality of water, manage waste and rainwater, expand water facilities, and reduce water losses.

The second phase (2028-2030) aims to strengthen the basic conditions for sustainable water management, aligning with the United Nations' Sustainable Development Goals such as "Clean Water and Sanitation," "Climate Action," and "Life Below Water."

The final phase (2031-2040) will focus on effectively managing hydro-ecological crises through innovative technologies, expanding the use of alternative water sources, and ensuring sustainable access to high-quality water.

The NWS outlines plan for the construction of new reservoirs, the development of smart water management systems, and increased use of desalination and recycled water. It also emphasizes the need for cross-border cooperation on water management, especially with neighboring countries such as Türkiye, Georgia, Russia, and Iran.

The document highlighted the importance of adapting to global climate trends and addressing regional water challenges as key components of the strategy. The initiative is expected to boost Azerbaijan's resilience to climate change and support sustainable agricultural development, energy security, and environmental protection.

The document contains comprehensive Action Plan. The adopted document contains Actiion Plan for Implementation of the NWS during 2024-2027 with the five priorities, which includes assessment, efficient management, usage of water resources, including in Karabakh and East Zangezur economic regions as well as water security measures such as transboundary water management, protection of water bodies and others. The approval of the NWS marks a significant step in Azerbaijan's efforts to secure its water future amid growing concerns over water scarcity and climate change impacts.

The latest changes in the institutional structure of the water sector governance by the establishment of *Azerbaijan State Water Resources Agency*, aims at the establishment of the single water authority to implement unified water policy in the country and eliminate fragmentation and overlapping of responsibilities of water related organizations.

Releasing of the occupied lands from Armenia, Karabakh and Shergi Zangezur regions, with the reach, freshwater resources after 2020 also contributes increasingly to the total water resources in the country. One of the important waters related activities is complete replacement of the destroyed water infrastructure in released areas. Currently the replacement of restoration of the hydraulic structures destroyed during the occupation period is going on, which is one of the major factors for resettlement of refugees and displaced people the released territories, including realization of the regional programs for development of agriculture, industry, services and other sectors. The infrastructure of the newly constructed cities and settlements, including water supply and sanitation services are being rebuilt based on the green solutions with the wide application of the smart city models.

The government decisions are adopted lately for the reconstruction of the Karabakh and Shirvan main irrigation canals, which are largest earth canals in the country. These canals will be constructed with a concrete lining and will be operated using modern management models.

In *Kazakhstan* one of the priorities of the sustainable development policy is to ensure the well-being of the population, the introduction of environmental technologies, the creation of environmentally friendly water resources, providing the regions of the country with clean water, and much more. Important changes have taken place in the country's water sector, and positive dynamics are beginning to be determined not only by intentions, but also by real actions aimed at improving the quality of fresh water and the entire water fund (Yessymkhanova, et al, 2021).

The geographical location of Kazakhstan plays crucial role in shaping a distinctly continental climate. This positioning has led to Kazakhstan facing a significant challenge in terms of water resource availability (Kakabayev et al., 2023; Tursunova et al.) In the country, 56% of surface water formed internally, and remaining 44% is the flows of transboundary rivers from China, Uzbekistan, Russia and Kyrgyzstan. The main volume of water resources or 74% is used by the agricultural sector, During 2015-2023, the area under sprinkle irrigation increased from 75.7 to 214.1 thousand ha, and the area of drip irrigation increased from 60.8 to 95.3 thousand ha (Government of Kazakhstan, 2024).

The expected trends of increasing water consumption and decreasing water availability threaten the growth of the regional deficit, which water basins of the country may face by 2040. If the efficiency of water resources uses and management is not improved, then by 2040 the water shortage will increase, which will negatively affect the supply of water to the population, GDP growth and the state of the environment (Yessymkhanova, et al., 2021).

Water Resources Management Program for 2020-2030 defines integrated measures to overcome challenges associated with decrease of surface water flows by 23.2 km^3, increasing demand for the water resources. The increase in the volume of water consumption by the population is expected by 35%. The main target indicators are i) area of irrigated lands, ii) the growth of the area covered by water-saving irrigation technologies and iii) reduction of water losses in irrigation main and distribution canals. These indicative milestones will be achieved by the construction of new hydraulic structures, improvement of irrigation and drainage networks, revision of mechanisms for subsidizing water-saving irrigation technologies and the reconstruction, major repairs and modernization of hydraulic facilities.

Improving interstate water relations will be achieved by the strengthening of international cooperation on issues of water resources management and quality; development and implementation of unified systems for water accounting and transboundary basins management, regional on-line monitoring systems, development of conceptual regional water strategies for transboundary basins based on the principles of integration with the drafting relevant interstate legal and regulatory acts.

Measures to improve the efficiency and rational use of water resources include revising the tariff policy, improving water legislation, radically improving the personnel training system and conducting targeted research work (Imamaliyev, 2023). The program targets a reduction in water losses in agriculture during transportation through main and inter-farm canals by 25% and savings in irrigation water by introducing water-saving irrigation technologies by 690x10^6 m^3 by 2030.

By the adopted action plan it is intended construction of the 20 new reservoirs and 15 existing reservoirs will be reconstructed. Information and analytical center for water resources and a national hydrogeological service planned to be established. Digitalization and automation of water metering on main and inter-farm irrigation canals will support precise water accounting. Additional agreements between the Republic of Kazakhstan and neighboring countries in the field of joint management and use of transboundary water bodies is intended to be concluded (Government of Kazakhstan, 2024).

In *Kyrgyzstan* water resource management is a key aspect of ensuring sustainable development and environmental safety. Due to the unique geographical location and climate characteristics, the country water resources play a particularly important role in supporting the economic development and livelihoods not only for the country but for the other riparian countries (Madaliev et al., 2024). Over the past 50-60 years, the glaciers of the Tien-Shan and Pamir have decreased from 60 to 40%, which is evidenced in the ongoing impact of climate change on the availability and sustainability of water resources in Kyrgyzstan (Farinotti et al., 2015). Climatic changes in the Tien Shan Mountains affect the inter-annual and intra-annual distribution of river flow. Global warming, which has intensified since the 1970s, is accompanied by an increase in the annual precipitation in the Tien Shan mountains. There is an increase in the duration of the warm period, over the past 20 years, according to the weather stations data in the Naryn river basin, the transition of positive air temperatures through 0oC is observed 10-15 days earlier, and towards negative temperatures later (Kalashnikova et al.,2023). The Syr Darya river basin encompasses 55.3 % of Kyrgyzstan's. The flow of the Syr Darya river is of vital importance for agricultural activities and the overall water balance within Kyrgyzstan and its neighboring countries. The river basins of Chu, Talas, and Assa encompass approximately 21.1 % of Kyrgyzstan's and flow towards Kazakhstan. Approximately 3.9 % of the Amu Darya river basin encompasses of Kyrgyzstan's territory. This demonstrates the interconnections of water resources between the riparian countries and the role that Kyrgyzstan in the formation of hydrological balance of the Amu Darya River basin. According to the climate change prognosis, it is expected to rise 2°C by 2060 (Broka et al., 2016). The combination of higher temperatures and reduced summer rainfall will significantly heighten the risk of drought across the country and will have wide-ranging impacts on the local agriculture and water resources.

To address the challenges associated with climate change, the Kyrgyz government has undertaken various initiatives to modernize the water sector and improve water management. The National Water Resources Management Project (NWRMP), supported by the World Bank, has focused on rehabilitating and upgrading irrigation and drainage (I&D) infrastructure, strengthening institutional capacities for integrated water resources management (IWRM), and promoting the use of water-efficient technologies.

The main sectoral objectives and indicators related to water are reflected in the strategic and program documents of the country are i)National Development Strategy of the Kyrgyz Republic for 2018-2040 ; ii)National Development Program of the Kyrgyz Republic until 2026;iii) State program for the development of irrigation of the Kyrgyz Republic for 2017-2026; iv) Program for the development of drinking water supply and sanitation systems in populated areas of the Kyrgyz Republic until 2026 (Government of Kyrgyzystan, 2023).

At present, a high ranked National Council on Water and Land Resources has been established. The main tasks and functions of the National Council are to coordinate the activities of ministries, administrative agencies, and other state bodies in the management, utilization, and protection of water and land resources.

As a country situated in a transboundary river basin, Kyrgyzstan is interested in strengthening regional cooperation and developing the necessary legal and institutional frameworks for effective management of shared water resources. Strengthening regional integration is important for Kyrgyzstan in its efforts to achieve sustainable and cooperative management of transboundary water resources, which contributes to the overall prosperity and welfare of Central Asia.

At present, Kyrgyzstan's legal policy in this area aimed at settling relations with neighboring states and concluding bilateral international agreements, using the successful experience of multilateral cooperation on the use of international watercourse systems in other regions of the world and models developed within the framework of the UN and other organizations (Dzhumagulov et al., 2024).

Turkmenistan water resources depend on the transboundary flows of Amu Darya and other rivers such as Murgab, Tedzhen and Atrek. As a transboundary river, Amu Darya shared by Afghanistan, Kyrgyzstan, Tajikistan, Turkmenistan, and Uzbekistan. Approximately 90% of Turkmenistan's water resources are derived from the Amu Darya River. While the international agreements covering the use of the Amu Darya allocate 36% of its annual flow to Turkmenistan, only 1% of the Amu Darya's flow is formed on the territory of the country. To satisfy water demand, intake from the Amu Darya is supplemented by surface runoff from the Murgap, Tedjen, and Atrek rivers, as well as other small springs. Groundwater also makes up a marginal part of Turkmenistan's water resources. In total, there are 3.4 km^3 of groundwater reserves, between 0.4 - 0.5 km^3 from which is used for water supply (Taganova et al., 2022).

A warming trend has been observed in all regions of Turkmenistan in recent decades. The average temperature across the country rose by approximately 2°C between 1950 and 2010, equivalent to warming of approximately 0.3°C per decade. The effect of climate change on the glaciers that feed the main tributary of the Amu Darya River, indicates that temperature rises of between 2.2 and 3.1°C by 2050 in mountainous areas would lead to a loss in glacial mass of 36–45% relative to present levels. Inflow into the downstream areas of the river could decline by 26–35% by 2050, even as water demand rises to allow continued irrigation in the face of higher evaporation rates. This projection implies that by 2050 there could be a severe water shortage in the Amu Darya River basin, with approximately 50% of demand being unmet. This situation may contribute to increased evaporation, accelerating the process of soil salinization, which is already taken place in 60% of the agricultural lands due to traditional irrigation practises, as well as reduction of crop productivity (WB&ADB, 2021).

In order for mitigate the consequences of the climate change and sustainable development, Turkmenistan focuses on improving irrigation systems and sustainable water use in agriculture. The national water strategy aims to ensure water security and improve water efficiency, which includes improving, modernization of the irrigation systems, canals and introducing drip and sprinkler irrigation. The country is implementing major reservoir construction projects, such as the Altyn Asyr project, which involves construction of artificial lake in the Karakum Desert to collect and store agricultural runoff (Myratberdiev et al.,2023). These reservoirs serve to regulate water flows, store water during floods, and ensure a sustainable water supply during dry period.

Turkmenistan's Water Strategy focuses on sustainable water use, especially in agriculture. This includes the introduction of farming technologies that help reduce water consumption, such as growing drought-resistant crops and optimizing irrigation schedules. Measures are also taken to protect water resources and prevent their pollution. Infrastructure development covers also modernization of water supply infrastructure and construction of new water disposal facilities are aimed at improving water supply to cities and rural areas. This contributes not only to improving the quality of life of the population, but also to the sustainable development of agriculture and industry. Thus, the current national strategy of the country demonstrates an integrated approach to ensuring water security and sustainable development of agriculture sector (Jalilova,2024). Recently transboundary cooperation with Uzbekistan is intensified by the intergovernmental cooperation (Government of Turkmenistan, 2021).

Türkiye's current water security policy comprises a set of strategic objectives, such as increasing agricultural production and ensuring food security, meeting the growing water needs of urban and rural populations as well as industry, eliminating regional, economic and social imbalances within the country and raising the population's living standards (Kibaroğlu,2022). The country with the geographically and climatically diverse conditions with the mountains, plains and coastal areas exposed to the influences of the on-going climate change. By the end of this century, Türkiye and the Middle East region are expected to have an increased mean temperature about 3–5 °C and a 20–40 % decline in precipitation.

According to climate change scenarios, the per capita of water potential will be decreased to 700-1910 m^3/year in 2050. Gross irrigatable area in Türkiye is 8,5 million ha, and the whole of this area will be irrigated by the year 2030. Water requirement for this area is estimated to be 71.5x 10^9 m^3, however, in total consumption; the percentage of irrigation is expected to drop from 75 to 65 % due to the water shortage (Bayram & Öztürk, 2021).

In Türkiye, potential adaptation measures that the drinking water, agriculture, and industrial sectors can take against climate change include reducing loss and leakage rates in drinking water supply, implementing rainwater harvesting, using water-saving fixtures in showers and toilets, and reusing domestic wastewater. In the agriculture sector, it is important to select crop patterns suitable for climate change, completely abandon flood irrigation, promote efficient irrigation techniques like drip irrigation, apply deficit irrigation where appropriate, and adopt organic farming and good agricultural practices, while also improving irrigation efficiency and raising farmer awareness. For industrial facilities, promoting clean production practices, enhancing internal controls, establishing a zero-discharge approach, and recovering wastewater for reuse in processes and similar applications are essential (Capar, 2019).

Over the last years, the country initiated a comprehensive process of planning for the watershed protections following international agreements. Türkiye has accomplished some great strides in some aspects of water resource protection and management over the last years. The number of protected areas in the water basins has been increased, various inter-basin projects have been initiated to supply drinking water in the cities, suitable crop patterns have been determined agricultural basins; and organic agriculture have been encouraged through farmers' training in water resources. In addition, three strategies can contribute to creating a holistic water resource plan which are public and water user participation in the water resource planning, integration of "water management" and "land-use planning" through appropriate and water sustainability, as a scope should be regarded in the national policy, regional and provincial plans (Pouya & Turkoglu,2020).

Because of natural conditions and basic political decisions on national development, Türkiye, like its neighbours, relies heavily on water for irrigation and hydropower production –with water being an important and, in some respects, strategic resource for the national economy standards While national political and economic interests have played a direct role in the formation of Türkiye's transboundary water security policy, international water law principles and rules have also had important effects. (Kibaroğlu, 2022). Although a number of bilateral protocols and other arrangements have been successfully agreed upon and signed, they need to be updated and therefore cooperation with the riparian countries is advisable to be deepened for the benefit of the involved countries.

In *Uzbekistan*, about only 10% of total volume of water resources available for use is formed on the own territory of the country and about 90% are water coming from transboundary sources, originated in upstream neighbouring countries (Sokolov, 2022). Uzbekistan is the largest consumer of water resources in Central Asia, especially of water originating from Kyrgyzstan (Janusz-Pawletta, & Gubaidullina, 2015). Uzbekistan is on the list of 27 countries experiencing high water scarcity, ranked 25th among 164 countries facing water shortages. The country's annual water resources estimated at 50–60 km^3, from which only 12.2 km^3 originates within the country, while the remainder flows from external sources. A significant portion of these resources is allocated to irrigating cotton fields. Available water resources are anticipated to decrease by 7-8 km³. Consequently, the current water resource deficit of 13-14% is forecasted to surge to 44-46% by 2030, posing significant challenges to agricultural and industrial development (CANECCA, 2023). Furthermore, water demand in Uzbekistan is expected to rise from 59 km^3 to 62-63 km^3 by 2050, while available water resources are expected to decline from 57 km^3 to 52-53 km^3. This escalation in water scarcity, from a current deficit of 2 km^3 to 11-12 km^3, represents a fivefold increase, posing substantial challenges to the country's agricultural and industrial growth (Giritlioglu & Tsoy, 2024).

The adopted *Concept for the Development of Water Resources of the Republic of Uzbekistan for 2020–2030 and Water strategy* aims to achieve significant developments in water sector. It is the basis for development of the "Strategy for management of water resources and development of the irrigation sector" and programs for the further development. The program plans to increase irrigation systems' efficiency from 0.63 to 0.73, irrigated lands with poor water supply to decrease from 560,000 to 190,000 ha, saline irrigated land areas decrease by 226,000 ha. The annual volume of electricity consumption by the state pumping stations is planned to decrease by 25%. To improve water use monitoring system, smart water devices will be installed at key irrigation facilities and water management processes automated at 100 key hydraulic structures. The area of the agricultural lands with the drip irrigation is intended to reach 600000 ha, which success depends on the availability of underground water. The integrated action plan also includes 50 public-private partnership projects implementation in the water sector.

The Ministry of Water Resources, currently, as a single state body is responsible for implementation of a unified national policy in the field of water resources management, formation of accounting, reporting and balance of water, as well as coordination of the activities of the public bodies and other organizations in the field of rational use and protection of water resources, prevention and elimination of the negative impact of water disasters (Sokolov, 2022).

Successes have been made in transboundary water management; interstate relations with Kyrgyzstan have seen significant positive developments in international water use. An intergovernmental agreement on the interstate use of the Orto-Tokoi (Kasansai) reservoir in Ala-Buka district of Jalal-Abad province of the Kyrgyz Republic was signed in 2017, 92% of the water from this reservoir is used by Uzbekistan for irrigation of 28,000 ha and 8% by Kyrgyzstan for 1,500 ha of land. The countries agreed to bear the related operational costs in the same proportion. In 2022, there was the signed Law on Ratification of the Agreement on the Joint Management of Water Resources of the Kempir-Abad (Andijan) Reservoir between the governments of Uzbekistan and Kyrgyzstan. In upcoming years more attention will be given for the transboundary cooperation. The states given their natural and climatic conditions, geopolitical location, globalization processes and common history, will have to find smooth and mutually beneficiary solutions on the joint water use by concluding bilateral international agreements, using the successful experience of multilateral cooperation on the use of international watercourse systems in other regions of the world and models developed within the framework of the UN and other organizations (Dzhumagulov et al., 2024).

Figure 1 (Soliev & Theesfeld,2020) clearly illustrates how as OTS member countries Kazakhstan, Kyrgyzstan, Turkmenistan and Uzbekistan are interconnected with shared water resources. Other riparian countries also use the basins' water resources. Therefore, deepening transboundary cooperation is vital for all basin countries and their sustainable development, which requires joint efforts to agree and implement mutually beneficial solutions for sustainable use of the shared water resources.

Figure1. The Water Resources in Central Asia

II. COMPARATIVE ANALYSES ON WATER RESOURCES AND USE IN MEMBER STATES

Key water related indictors in the OTS member countries differs from each other, originating from their geographic location, climatic conditions, number of populations, water resources availability and main economic activities.

In comparison with the other member countries the total water resources in Türkiye are higher, and less water can be observe in Turkmenistan. However, for the case of Türkiye, despite that the country is the source of the several big river basins such as Tigris-Euphrates, the Choruh, and the Kura, the water resources per capita is emergingly small, which demonstrates that the country is under high water stress. Uzbekistan also has limited volume of water per capita, Azerbaijan and Turkmenistan are approximately with the same position, Kyrgyzstan has more water per capita, Kazakhstan is second member country with the relatively high-water resources per capita.

In the member countries, irrigation is the main source for agricultural production and remains an important part of the GDP for the national economies. The share of agriculture in the structure of GDP in Azerbaijan and Kazakhstan is approximately the same, amounting to 5.5% (SSC of Azerbaijan, 2023) and 5.2% (Statista, 2024), respectively. The share of agriculture in the Kyrgyz Republic's gross domestic product was 10.94% in 2022 (NSCKR, 2022). In Turkmenistan, Türkiye and Uzbekistan, these amounts are 11.6% (The Global Economy, 2023), 6.2 % (Trading Economies, 2023) and 7.5% (Uzbekistan - Country Commercial Guide, 2023) respectively. The climate change has direct influence on the water resources, high temperatures initiate more evaporation and has negative influence on the pasture productivity, subsequently to the agriculture and husbandry.

The water consumption per ha also gives clear idea on the efficiency of water use in irrigation. Among the member states, more irrigated lands in Türkiye, but irrigation water for per ha is less in comparison with the other member countries because of the relatedly more intensive application of modern water saving irrigation technologies such as drip, piped and sprinkler systems (Table 1). However, in places where surface irrigation technologies remained, technological water losses are high, as in other member countries.

In general, the water consumption per ha in member countries remains high, varying to the prevailing earth irrigation canals, where technologically water losses occur during the delivery and irrigation in the field, originating from poor water distribution along the fields. The irrigation water consumption per ha in member countries varies between 2,169-9,000 m^3/ha (Table 2). The water consumption depends on the location of the country, air temperature, crop type and subsequently from crop water requirement, but also on the technical condition of the irrigation system and uniformity of the fields. Unproductive water losses during the irrigation percolate into the soil, raising groundwater levels and contributing to soil salinization. Soil salinization has become a serious problem in agricultural practice almost in all OTS member countries, leading to land degradation and partly loss of their productivity.

Table 1. Basic water related indicators in OTS member countries

No	Country	Total water resources, 10^9 m^3	Water taken from the natural sorces, 10^9 m^3	Consumed total water, 10^9 m^3	Population, 10^6 inhabitants	Water resources, per capita, m^3/person
1	Azerbaijan	37,9 [1]	13,743 [2]	10,526 [2]	10,180 [3]	3723
	Sources:	1. Cabinet of Ministries of Azerbaijan (2023). Annual water economy balance of the Republic of Azerbaijan. Approved by the Decree No. 755 of the Cabinet of Ministers of the Republic of Azerbaijan dated September 5, 2023. 2. SSC of Azerbaijan(2023). Environment in Azerbaijan. Water resources. Statistical yearbook. https://www.stat.gov.az/menu/6/statistical_yearbooks/ 3. SSC(2024). Demographic indicators of Azerbaijan. Statistical yearbook. Chasioglu-EI MMC publication house				
2	Kazakhstan	102 [1]	24,518 [2]	20,0 [2]	20,033842 [3]	5091
	Sources	[1] Концепция развития системы управления водными ресурсами Республики Казахстан на 2024-2030 годы. http://cawater-info.net/library/rus/legal_59.pdf [2] SSC of Azerbaijan (2023). Environment in Azerbaijan. International comparisons. Water abstraction from natural sources, its consumption, losses, and discharge of waste waters in CIS. Statistical yearbook. https://www.stat.gov.az/menu/6/statistical_yearbooks/ [3] Официальный сайт Бюро национальной статистики Агентства по стратегическому планированию и реформам Республики Казахстан https://stat.gov.kz/ru/industries/social-statistics/demography/publications/157456/				
3	Kyrgyzystan	51 [1]	8,8725 [2]	6,028 [2]	7,1619 [3]	7121
	Soures:	1. Yusupova, G. N., Yugai, N. A., Choguldurov, M. D., & Khubieva, S. A. (2024). Development of water resources infrastructure in the Kyrgyz Republic: conflict potential. In BIO Web of Conferences (Vol. 83, p. 04001). EDP Sciences. 2. National Statistical Committee of the Kyrgyz Republic. Environment. https://www.stat.gov.kg/en/statistics/turizm-otdyh-ohrana-okruzhayushej-sredy/ 3. National Statistical Committee of the Kyrgyz Republic. Population. https://stat.gov.kg/en/statistics/naselenie/				
4	Turkmenistan	25 [1]	21,78 [2]	19,25 [3]	7,570800	3090
	Sources	1. UNDP, 2012. Investment and Financial Flows (I&FF) Assessment Report Assessment of investment and financial flows to address climate change mitigation in the Water sector https://climatepromise.undp.org/sites/default/files/research_report_document/undp-iff-turkmenistan-assessment-water-en.pdf 2. UNDP,2023. Voluntary National Review of Turkmenistan on the progress of implementation of the Global Agenda for Sustainable Development 2023. https://sdg.stat.gov.tm/books/new_2023_ru.pdf 3. Stanchin, I., & Lerman, Z. (2007). Water in Turkmenistan. The Hebrew University of Jerusalem. Discussion Paper No. 8.07 https://ageconsearch.umn.edu/record/7142/?v=pdf				

Continuation of Table 1

5	Türkiye	112 [1]	63,2 (19.2* +44) [2]	58,41 [3]	85,372377	1346 [1]
	Sources:	1. Toprak Su Kaynakları. Tarım ve Orman Bakanlığı Devlet Su İşleri Genel Müdürlüğü https://dsi.gov.tr/Sayfa/Detay/754 Access date: 08.07.2024 2. Water and Wastewater Statistics, 2022 . Retrieved from: https://data.tuik.gov.tr/Bulten/Index?p=49607&dil=2 3.Öztürk, A., & Çolak, M. S. (2024). A Quantitative and Qualitative Assessment of Türkiye's Water Resources Potential. Journal of Agricultural Sciences, 30(1), 1-34. https://dergipark.org.tr/en/download/article-file/3032349				
6	Uzbekistan	62,93* [1]	52 [2]	49,16 [3]	37,134200 [4]	1695
	Sources:	Note:* 11,5 (surface runoff of internal rivers)+ 42.0 (transboundary rivers)+ 9.43 (return and underground waters). 1. Amanov et al.,2023. Assessment and forecast of water resources use in Uzbekistan. In E3S Web of Conferences (Vol. 452, p. 02001). EDP Sciences. https://www.e3s-conferences.org/articles/e3sconf/pdf/2023/89/e3sconf_ipfa2023_02001.pdf 2. Ministry of Ecology, Environmental Protection and Climate Change of the Republic of Uzbekistan (2024). National Report on the State of the Environment. Republic of Uzbekistan. https://unece.org/sites/default/files/2024-02/Non-technical%20Illustrative%20Summary%20of%20UZB%20NSoER.pdf 3. FAO,2012. Country profile-Uzbekistan. https://openknowledge.fao.org/server/api/core/bitstreams/04340419-518f-4d46-b6f1-3dcaa0d1b230/content 4. Statistics Agency under the President of the Republic of Uzbekistan. Demographıc sıtuatıon ın the Republıc of Uzbekıstan https://stat.uz/img/demografiya-english-_p16588.pdf				

Water management reforms in the member countries stipulate promotion of market principles to reduce water demand. For encouragement of better irrigation, water management and water conservation, all member countries apply water charges. Operation and maintenance (O&M) of hydraulic structures are mostly financed by the state budgets. In the case of on-farm irrigation systems, WUOs are participating in O&M also, which costs is covered through both state budgets and fees collected from water users for provided irrigation services. Tariff rates for irrigation services differ, depending on country. In Azerbaijan the irrigation water tariffs are the same since 2006 and small, as by subsidizing the irrigation water costs, the government supports farmers and welfare in the rural places. In Kazakhstan currently government applies differentiated water tariffs and irrigation water tariffs are approved for each region according to climatic peculiarities of the area. In Kyrgyzstan the water delivered to WUAs, is adjusted to 0.0004 USD/m^3 in 2021 based on the KGS/USD exchange rate. Based on this tariff, WUAs charge additional fees to cover the costs of administration and O&M of the irrigation network down to the farms. In Turkmenistan irrigation water fee is fixed on the calculated yearly water supply services cost (0,0298 TM) and cropping pattern. The actual amount of the irrigation water fee is calculated by multiplying of the water supply services cost by irrigation norm of a specific crop. According to the government decision, 50-70% of irrigation water expenses is subsidized to support farmers. In Türkiye, irrigation water tariffs are applied to different type of tariffs depending on the region and irrigation method. There are, in some places where irrigation water tariffs are fixed on the basis of per ha of the crop, but in other places a volumetric approach is applied, i.e. per volume of irrigation water supplied. But the difference in tariffs between gravity and pumped irrigation is quite big. In Uzbekistan as in Azerbaijan, applied unified tariffs are used for irrigation water (Table 3). Irrigation water fees is relatively high in Türkiye and Uzbekistan, but in Kazakhstan and Azerbaijan relatively low and subsided by the public funds.

Reduction of water for irrigation, and expansion of the desertification requires finding efficient farming systems, promoting land fertility and water use efficiency in irrigation. Therefore, each country implements its own water and land policy. The current situation requires from the member countries to mobilize more investments for wide application of the modern farming technologies, otherwise sustainability of agriculture and social economic development in the regions will be damaged which may lead to migration of population from villages and disbalance in development of the rural areas.

Table 2. Irrigation related indicators of the in OTS member countries

Member country		Indicators				
		Irrigation/ agriculture water consumption, 10^9 m^3	Water losses in irrigation 10^9 m^3	Irrigated land, 10^6 ha	Irrigation water consumption per ha, m^3 /ha	The share of the earth canals, %
1	Azerbaijan	7,692 [1]	3,1 [1]	1,4849 [2]	5180	75 [3]
	Sources:	1. SSC of Azerbaijan (2023). Environment in Azerbaijan. Water resources. Statistical yearbook. https://www.stat.gov.az/menu/6/statistical_yearbooks/ 2. SSC of Azerbaijan(2023). Irrigated lands. https://www.stat.gov.az/source/agriculture/ 3. Ahmadzade A.& Hashimov A. Encyclopedia. Amelioration and Water Economy. AWM. Baku, Radius, 632 p., 2016.				
2	Kazakhstan	11,4 [1]	5,7 [1]	2,3 [2]	4957	73 [3]
	Sources:	1. Концепция развития системы управления водными ресурсами Республики Казахстан на 2024-2030 годы. http://cawater-info.net/library/rus/legal_59.pdf 2. Сводный аналитический отчет о состоянии и использовании земель РК за 2023 год. http://cawater-info.net/bk/land_law/files/kz-land2023.pdf 3. Vinokurov, E., Ahunbaev, A., Chuyev, S., Adakhayev, A., & Sarsembekov, T. (2023). Эффективная ирригация и водосбережение в Центральной Азии (Efficient Irrigation and Water Conservation in Central Asia). https://eabr.org/upload/iblock/6de/EDB_2023_Report-4_Irrigation_rus.pdf				

Continuation of Table 2

3	Kyrgyzystan	5,697 [1]	1,7-2,3 [2]	1,0485 [3]	5433	82 [4]
	Sources:	1. National Statistical Committee of the Kyrgyz Republic. Environment. https://www.stat.gov.kg/en/statistics/turizm-otdyh-ohrana-okruzhayushej-sredy/ 2. Water Resources Service of the Ministry of Agriculture of Kyrgyz Republic https://www.water.gov.kg/index.php?option=com_content&view=article&id=365&Itemid=1470&lang=en 3. National Statistical Committee of the Kyrgyz Republic. Land used by farms in Kyrgyz Republic. https://www.stat.gov.kg/en/opendata/category/181/ 4. FAO. 2012. AQUASTAT Country Profile – Kyrgyzstan. Food and Agriculture Organization of the United Nations (FAO). Rome, Italy https://openknowledge.fao.org/server/api/core/bitstreams/f094b9e9-f39e-4a59-a920-5d989a19f5f5/content				
4	Turkmenistan	22,8* [1]	6,3 [2]	1,8 [3]	5300 – 7000**	98
	Souces:	Note: 91,1 % of available water used for irrigation and agriculture; **depending on the crop type 1. UNDP, 2012. Investment and Financial Flows (I&FF) Assessment Report Assessment of investment and financial flows to address climate change mitigation in the Water sector https://climatepromise.undp.org/sites/default/files/research_report_document/undp-iff-turkmenistan-assessment-water-en.pdf 2. Orlovsky, N., & Orlovsky, L. (2002, June). Water resources of Turkmenistan: use and conservation. In workshop on water, climate, and development issues in the Amu Darya basin, Philadelphia, USA. https://www.researchgate.net/profile/L-Orlovsky/publication/228600445_Water_resources_of_Turkmenistan_Use_and_conservation/links/00463523837bc67489000000/Water-resources-of-Turkmenistan-Use-and-conservation.pdf 3. UN Climate Change (2022). Nationally Determined Contributions under the Paris Agreement. (Определяемый на Национальном Уровне Вклад по Парижскому соглашению) as https://unfccc.int/sites/default/files/NDC/2023-01/NDC_Turkmenistan_12-05-2022_approv.%20by%20Decree_Rus.pdf				
5	Türkiye	44 [1]	(15.4-26.4)* (2.2- 11)** [2]	7,1 [3]	2169-3718,3* 281.7- 1549,3**	71* 29** [4]
	Sources:	1.Toprak Su Kaynakları. Tarım ve Orman Bakanlığı Devlet Su İşleri Genel Müdürlüğü https://dsi.gov.tr/Sayfa/Detay/754 Access date: 08.07.2024 2. Tarımsal Sulama Sektör Politika Belgesi 2021-2025. Tarım ve Orman Bakanlığı Tarımsal Araştırmalar Ve Politikalar Genel Müdürlüğü, TAGEM, 2021. https://www.tarimorman.gov.tr/TAGEM/Belgeler/yayin/Tar%C4%B1msal%20Sulama%20SPB_2021-2025.pdf Access date: 08.07.2024 3.[1] DSİ 2023 Yılı Faaliyet Raporu. Tarım ve Orman Bakanlığı Devlet Su İşleri Genel Müdürlüğü Strateji Geliştirme Dairesi Başkanlığı. https://cdniys.tarimorman.gov.tr/api/File/GetFile/425/Sayfa/759/1107/DosyaGaleri/dsi_2023_yili_faaliyet_raporu.pdf#page=40				

Continuation of Table 2

		4. Tarım ve Orman Bakanlığı Devlet Su İşleri Genel Müdürlüğü,2021. https://www.dsi.gov.tr/Haber/Detay/1127 Access date: 08.07.2024 ***Note:*** In surface/flood irrigation* methods, water loss occurs (ranging from 35% to 60%), whereas in modern (sprinkler and drip) irrigation**, water loss is less (ranging from 5% to 25%) for Türkiye.				
6	Uzbekistan	46,8* [1]	14,75 [2]	4,3 [2]	8000 – 9000**	60 [4] 77
	Sources:	1. Ministry of Ecology, Environmental Protection and Climate Change of the Republic of Uzbekistan (2024). National Report on the State of the Environment. Republic of Uzbekistan. https://unece.org/sites/default/files/2024-02/Non-technical%20Illustrative%20Summary%20of%20UZB%20NSoER.pdf 2. GoU (2020). Concept of development of water management of the Republic of Uzbekistan for 2020-2030. (Концепция развития водного хозяйства Республики Узбекистан на 2020-2030 годы). https://lex.uz/docs/-4892953?ONDATE=06.02.2024%2000 3. Abdullaev, I., De Fraiture, C., Giordano, M., Yakubov, M., & Rasulov, A. (2009). Agricultural water use and trade in Uzbekistan: Situation and potential impacts of market liberalization. International Journal of Water Resources Development, 25(1), 47-63. https://www.zef.de/fileadmin/user_upload/5d18_Abdullaev_revise.pdf 4. Khamraev et al. (2020). Irrigation and Drainage in Republic of Uzbekistan: History and Modern State. Ministry of Water Resources of the Republic of Uzbekistan. https://icid-ciid.org/icid_data_web/UzNCID_book_web_en.pdf Note: * calculated- 90% from the all consumed water; ** with water losses; *** 60% of inter-farm canals and 77% of on-farm canals have an earth (not lined) canals.				

Table 3. Irrigation water tariffs in OTS member countries

Country		Irrigation water tariff	
		National currency	USD
1	Azerbaijan		
Irrigation of fields, 1,000 m^3		0.5 AZN	0.29
Irrigation of winter pastures and meadows, AZN/ ha		0.4 AZN	0.24
Source: Decision of the Tariff (Price) Council of the Republic of Azerbaijan. About the tariffs of paid water use services provided by Azerbaijan Reclamation and Water Management Open Joint Stock Company. Retrieved from: https://e-qanun.az/framework/15693 Exchange rate: 1 AZN=0.59USD			
2	Kazakhstan		
The Ishim River basin		145,73 KZT	0.30 USD
Balkhash, Alakol rivers and lakes basin		69,32 KZT	0.15 USD
The Irtysh River basin		76.86 KZT	0.16 USD
Nura, Sarysu, Kengir river basins		84.39 KZT	0.18 USD

Continuation of Table 3

Turgai, Tobol, Irgiz river basins	72.34 KZT	0.15 USD
Kostanay region	160.4 KZT	0.33 USD
South Kazakhstan region	5.4 KZT	0.01 USD
Note: In Kazakhstan, water tariffs are differentiated and approved for each region according to climatic peculiarities of the area. Exchange rate: 1 KZT =0.0021 USD. *Source:* Информационно-правовая система нормативных правовых актов Республики Казахстан Әділет. https://adilet.zan.kz/rus/docs/V23K0638309 ; https://www.gov.kz/memleket/entities/kgd-sko/press/article/details/123719?lang=ru		
3 Kyrgyzstan		
Irrigation water fee, 1000 m^3	40 KGS	0.4
Source: Water Resources Service of the Ministry of Agriculture of Kyrgyz Republic. Exchange rate: 1KGS= 0.012 USD. https://www.water.gov.kg/index.php?option=com_content&view=article&id=365&Itemid=1470&lang=en		
4 Turkmenistan		
Irrigation of fields, TMT/ha	Crop name	
It is calculated by multiplying the cost of water supply service of 0,0298 TMT/m^3 by the irrigation water requirement rate of specific crop per 1 ha.	Watermelon: 4.7 TMT Cotton: 6.2 TMT Rise: 26.6 TMT Fodder: 7.2 TMT Fruits: 7.55	1.34 1.77 7.5 2.1 2.2
1 TMM= 0.29 USD *Source*: Government of Turkmenistan.		
5 Türkiye		
Per ha of land cultivated		
Gravity irrigation, ha	450 - 5110 TL	13.6 -154.8
Pumped irrigation, ha	1400 - 13630 TL	42.4 – 412.9
Per volume of water supplied		
Gravity irrigation, 1000 m^3	170 - 290 TL/1000 m^3	5 – 9
Pumped irrigation, 1000 m^3	390 - 780	12 - 24
Source: Tarım ve Orman Bakanlığı, 2024. https://cdniys.tarimorman.gov.tr/api/File/GetGaleriFile/425/DosyaGaleri/603/sukulhizbedlitarifesb2024.pdf Access date: 10.07.2024 *The exchange rate for the currency conversion is based on the date of July 10, 2024*		
6 Uzbekistan		
Irrigation of fields, 1000 m^3	100000 UZS	7.90
Note: Uzbekistan water tariffs are regulated by Law of the Republic of Uzbekistan No. ORQ-891 of 28.12.2023. Exchange rate: 100UZS = 0.0079 USD Source: GoU (2023). National Legislation Database, 29.12.2023, No. 03/23/891/0989 https://lex.uz/docs/6718864#6720619		

The collected irrigation service fees in the most member countries are not enough to cover O&M and, even more, ensure high quality of O&M of irrigation and drainage systems that are under responsibility of WUOs (OECD, 2020).

Raising tariffs for irrigation services for reliable water supply requires establishing precise water accounting system and installation of new irrigation systems with advanced irrigation technologies. This task is necessary but require implementing targeted integrated projects in the member countries. It will also raise financial capability of farmers to pay for irrigation services in time due to the rising of crop productivity from well managed farming process.

Water tariffs for municipal water supply also differs in the member counters (Table 4).

Table 4. Water supply in Turkic countries

<table>
<tr><th rowspan="2">No</th><th rowspan="2">Member country</th><th rowspan="2">Domestic and drinking purposes per year, 10^6 m^3</th><th rowspan="2">Daily consumption norms, per capita, Liter/day</th><th colspan="2">The connection rate to the centralized water supply, %</th><th rowspan="2">Drinking water tariffs, USD/m^3</th><th rowspan="2">Average continuity of the water supply, hours/day</th></tr>
<tr><th>Cities</th><th>Rural places</th></tr>
<tr><td rowspan="3">1</td><td>Azerbaijan</td><td>329 [1]</td><td>125-160*
160-230**
230-350***
[2]</td><td>94.9
[3]</td><td>37.7
[3]</td><td>0.41^{x}
0.35^{xx}
[4]</td><td>19.8
[5]</td></tr>
<tr><td colspan="7">Note: *without bath; **with local water heaters and bath; ***with centralized hot water supply.
ˣBaku, Sumgait cities and Absheron rayon; ˣˣ other regions of the country
Sources:
1. SSC of Azerbaijan (2023). Environment in Azerbaijan. Water resources. Statistical yearbook. https://www.stat.gov.az/menu/6/statistical_yearbooks/
2. State Urban Planning and Architecture Committee, 2015. National Standard AzDTN 2.11-1. Water supply. External network and facilities. https://www.arxkom.gov.az/qanunvericilik/normativler/muhendis-sistemleri/su-techizati-xarici-sebeke-ve-qurgular</td></tr>
<tr><td colspan="7">3. SSC of Azerbaijan (2024). Results of household surveys. Statistical Collection. https://stat.gov.az/menu/6/statistical_yearbooks/source/evtes_2024.zip
4. Tariff Council of the Republic of Azerbaijan (2021). Resolution No. 5 of the Tariff (Price) Council of the Republic of Azerbaijan dated January 30, 2021 "On approving tariffs for water supply and waste water discharge services" https://tariff.gov.az//storage/media/2464/9C87AE17-78E8-4273-9334-5BEB6318D6AB.pdf
5. SSC of Azerbaijan (2022).The sıtuatıon of drınkıng water supply of the populatıon. Statistical
Collection. https://www.stat.gov.az/source/budget_households/az/bul/su_2021.pdf</td></tr>
<tr><td rowspan="2">2</td><td>Kazakhstan</td><td>671,941,900
[1]</td><td>25*; 100**
200***
280****
[2]</td><td>94 [3]</td><td>84.4 [3]</td><td>0.19^{x}
0.49-
$0,68^{xx}$
[4]</td><td>18 [5]</td></tr>
<tr><td colspan="7">Note:
*street water tap 25; ** running water and sewerage, no baths; *** water supply and sewerage, baths, with gas and electric water heaters; ****water supply and sewerage, central hot water supply, equipped baths (saunas)
ˣ population; ˣˣother residential consumers</td></tr>
</table>

Continuation of Table 4

	1. Bureau of National Statistics.Agency for Strategic Planning and Reforms of the Republic of Kazakhstan (2024). Environmental statistics. Domestic water consumption in 2023, https://stat.gov.kz/ru/industries/environment/stat-eco/ 2. Ministry of Justice of Kazakhstan (2017). Information and legal system of regulatory legal acts of the Republic of Kazakhstan. Standards for consumption of public utilities for water supply for consumers of the city of Almaty who do not have metering devices. Resolution of the Akimat of Almaty city dated April 27, 2017 No. 2/132. Registered by the Department of Justice of Almaty city on May 25, 2017 No. 1375 (Постановление акимата города Алматы от 27 апреля 2017 года № 2/132. Зарегистрировано Департаментом юстиции города Алматы 25 мая 2017 года № 1375). https://adilet.zan.kz/rus/docs/V17R0001375 3. Sailaukhanuly, Y., Azat, S., Kunarbekova, M., Tovassarov, A., Toshtay, K., Tauanov, Z., ... & Berndtsson, R. (2023). Health Risk Assessment of Nitrate in Drinking Water with Potential Source Identification: A Case Study in Almaty, Kazakhstan. International Journal of Environmental Research and Public Health, 21(1), 55. https://www.mdpi.com/1660-4601/21/1/55 4. Astana Su Arnasy (2024). Tariffs for water supply and sanitation for the period from August 1, 2024 to December 31, 2024. https://astanasu.kz/to-client/tariffs/ 5. OECD (2011). Ten Years of Water Sector Reform in Eastern Europe, Caucasus and Central Asia, OECD Studies on Water, OECD Publishing, Paris. https://doi.org/10.1787/9789264118430-en						
3	Kyrgyzstan	320.75 [1]	100-150* 250-300** 350*** [2,3]	64.1 [1]	10.0 [1]	0.12*** 0.081- 0.10** [2]	27%**** - 24 37% -> 12 36% - < 12 [4]
	Note: * rural areas; ** other cities; *** Bishkek; ****% of population supplied in hours per day Sources: 1. Government of the Kyrgyz Republic (2022). Program for the development of drinking water supply and sewerage systems until 2035. https://cbd.minjust.gov.kg/157536/edition/1037006/ru 2. Bishkek City Hall. (2024). Bishkek City Hall. https://bishkek.gov.kg/en/service 3. State Agency for Architecture, Construction and Housing and Communal Services under the Government of the Kyrgyz Republic (2021). Construction Norms of the Kyrgyz Republic. Water supply. https://cbd.minjust.gov.kg/38-7/edition/1235/ru 4. Government of the Kyrgyz Republic (2016). STRATEGY "for the development of drinking water supply and sewerage systems until 2026". https://cbd.minjust.gov.kg/99118/edition/1007057/ru						
4	Turkmenistan	333.2* [1&2]	323 (2021) [3]	85 [4]	42 [4]	0.14- 0.28 [5]	18 [4]

Continuation of Table 4

	Note: * as of the end of the 2010s *Sources:* 1. SSC of Turkmenistan (2022). Statistical yearbook of Turkmenistan 2. SSC of Turkmenistan (2022). Environmental Protection and Use of Natural Resources in Turkmenistan. Statistical Digest. 3. World Data Atlas. Turkmenistan. Water resources. https://opendataforafrica.org/atlas/Turkmenistan/topics/Water 4. OECD (2011). Ten Years of Water Sector Reform in Eastern Europe, Caucasus and Central Asia, OECD Studies on Water, OECD Publishing, Paris. https://doi.org/10.1787/9789264118430-en 5. Vinokurov, E. (ed.), Akhunbaev, A., Chuev, S., Adakhaev, A., Sarsembekov, T. (2024). Drinking Water Supply and Sanitation in Central Asia. Report 24/5. Almaty: Eurasian Development Bank (Питьевое водоснабжение и водоотведение в Центральной Азии. Доклад 24/5. Алматы:Евразийский банк развития) https://eabr.org/upload/iblock/3d6/EDB_Doklad_Drink_water_RU_web_2024_06_17.pdf						
5	Türkiye	6700 [1]	229 [1]	98.8 [1]	86 [2]	0.97*-0.11** [3]	24
	Note: highest* and lowest** household water usage tariff depending on metropolitan municipalities 1.TUIK, 2023. Su ve Atıksu İstatistikleri, 2022 https://data.tuik.gov.tr/Bulten/Index?p=Su-ve-Atiksu-Istatistikleri-2022-49607 2.Water supply and sanitation in Türkiye. https://en.wikipedia.org/wiki/Water_supply_and_sanitation_in_Türkiye 3.Sputnik Türkiye, 2024. https://anlatilaninotesi.com.tr/20240204/Türkiyede-en-uygun-fiyata-su-kullanan-sehir-belli-oldu-izmirden-10-kat-daha-ucuz-1080381483.html						
6	Uzbekistan	2300 [1]	50*-350 [2]	90.25 [3]	70.78% [3]	0.087-0.32 [4]	16**-23*** [5]
	Note: * for users of street water taps; **rural areas; ***urban 1. Ministry of Ecology, Environmental Protection and Climate Change of the Republic of Uzbekistan (2024). National Report on the State of the Environment. Republic of Uzbekistan. https://unece.org/sites/default/files/2024-02/Non-technical%20Illustrative%20Summary%20of%20UZB%20NSoER.pdf (Accessed August 28, 2024) 2. O'zsuvtaminot JCC (2024). Information about the norms of water consumption by the population and tariffs on JSC "Tashkent city water supply". https://uzsuv.uz/media/page/2024/04/toshshahar_rus_cpRScO4.pdf 3. Statistics Agency under the President of the Republic of Uzbekistan (2024). Environment and ecology statistics. Housing fund. https://siat.stat.uz/reports-filed/2631/table-data 4.O'zsuvtaminot JCC (2024). Information on tariffs for drinking and wastewater services. https://uzsuv.uz/uz/tariflar 5.UNECE (2015). Country Profiles on Housing and Land Management.Uzbekistan, p.71. https://unece.org/fileadmin/DAM/hlm/documents/Publications/cp.uzbekistan.2015.en.pdf						

According to Worldometer statistics, less daily water use per capita among the OTS members is Türkiye, most water consumption is Turkmenistan. In Azerbaijan, Kazakhstan, Kyrgyzstan and Uzbekistan it ranges between 3,512-4,778 litres per capita (Worldometer, 2024) (Table 5).

Table 5. Water use per country

No	OTS member country	Daily water uses per capita, (litres)
1	Azerbaijan	3,512
2	Kazakhstan	3,397
3	Kyrgyzstan	4,153
4	Turkmenistan	15,445
5	Türkiye	1,978
6	Uzbekistan	4,778

These figures highlight the significant pressure on water resources in the member countries, requiring careful consideration of sustainable water management.

From the countries' brief analysis, it can be derived that water is one of the most valuable resources of the region, supporting extensive agricultural development covering more than 18 million ha. in member countries. This development is relatively expensive, raising questions about long-term sustainability, both environmentally in terms of degradation of aquatic ecosystems, and financially due to high irrigation costs and low-cost recovery rates. The discussions among transboundary countries about the seasonality of hydroelectric power production and the availability of water for irrigation during the growing season is generally intensified by increasing droughts, events that are likely to become more frequent as the climate changes.

Necessary economic development and population growth certainly will lead to an increase in demand for water. By the 2050s, the demand for water is expected to rise, also because of higher demands and standards of water supply and sanitation services with the recognition of environmental safety of water. In Central Asian region, potential evaporation will increase by about 5% by 2050, leading to higher consumptive use by crops. Higher temperatures will lead to temporary increases in glacier meltwater in the short term, which will be replaced by lower flows as glaciers shrink. High variability in river water flow regimes is expected to persist, meaning that current water planning and management practices will need to be reconsidered. The water demand will increase, which, combined with increased supply variability and uncertainty, will lead to an estimated supply-demand gap of about 37% (ADB, 2021)

As water resources in the member states' regions are already fully allocated, this may lead to supply shortages for water users in future. A more comprehensive climate resilience scenario, including a broad portfolio of region-wide investment interventions, will therefore be required for optimization of the water use and protection. The key to the climate resilience scenario is to increase the efficiency of water consumption in all countries, considering the protection of aquatic ecosystems, which requires the development and implementation of comprehensive national and regional programs.

The establishment of the International Fund for Saving the Aral Sea (IFAS) is an excellent example of cooperation between the countries to overcome common ecological and water problem together and coordinate national and regional activities. From this point of view, the OTS can be turned into the effective working platform for the harmonization of national water legislation, achievement of regional agreements, the development of detailed working mechanisms and the implementation of the joint projects.

III. CONCLUSION AND RECOMMENDATIONS

The climate change and arisen associated challenges dictates to take more actions by the member countries. At present, member countries of the Organization of Turkic States are experiencing water related challenges that may threat not only economic development but also the lives of millions of people. The population of the member countries is growing rapidly, the territory of deserts area is gradually expanding, and water quantity reduction and worsening of their quality negatively affect the water consumption and quality of life. Strategically, for the long-term future actions recommendable measures for the member countries are summarized in Box below.

In upcoming *short and medium term*, these main activities are advisable to be concentrated upon, and the implementation of the following measures:

The main priority for the countries shall be to ensure availability and sustainable management of water and sanitation for all, as stipulated in UN SDG 6. The task for universal and equitable access to safe and affordable drinking water for everybody is recognized by the member countries, which shall be implemented gradually as an urgent task.

Improvement of the national water legislations shall consider the continued climate change and reflect policy attitude for the future vision and improve management of the water resources aiming at rational use and environmental protection of the water resources;

Infrastructure upgrading is essential for transferring into the precise farming systems in member countries, gradually reducing and elimination of inefficient water losses in agriculture. The process of application of modern irrigation technologies shall be accelerated and targeted wide application of the modern irrigation systems, through implemented national programs and projects, but the process can be sped up by the increase of the direct investments and enhancing of the encouragement mechanisms for the farmers in all member countries;

Land consolidation process is advisable to be enlarged, enabling establishment of the modern efficient farm systems and efficient agricultural water use;

The elaboration of the unified water related data obtaining processing and monitoring systems and exchange of experiences also would be solid bases for the improvement of the water management systems in the member countries.

Box. Recommendations for the future water strategy of the Turkic countries for the sake of long-term sustainability of national economies and cooperation

No	Description	Action
	Integrated Water Resources Management (IWRM)	
I	Promote a holistic approach to water management that considers the interconnectedness of water resources, ecosystems, and human needs. IWRM encourages collaboration across sectors and countries to optimize the use of water resources	• Develop shared water databases and monitoring systems • Foster regional policies that align national water management plans. • Encourage multi-stakeholder dialogues involving government, civil society, and private sectors.
	Regional Cooperation and Agreements	
II	Strengthen regional cooperation through treaties and agreements that promote equitable water sharing and joint management of transboundary water resources	• Create a regional water governance body to oversee cooperation. • Negotiate fair water allocation agreements that consider upstream and downstream needs. • Develop conflict resolution mechanisms to address disputes over water use.
	Water-Efficient Agricultural Practices	
III	Encourage sustainable agricultural practices that reduce water consumption and improve water use efficiency	• Promote drip, subsoil, sprinkler irrigation, soil moisture management systems and crop rotation techniques. • Support the adoption of drought-resistant crops and efficient irrigation technologies. • Provide training and resources for farmers to implement water-saving practices.
	Public Awareness and Education	
IV	Raise awareness among local communities and stakeholders about the importance of sustainable water management and the impacts of climate change	• Implement education campaigns on water conservation and climate adaptation strategies. • Encourage community-based water management initiatives. • Provide resources and support for schools and local organizations to teach sustainable water use practices.
	Investment in Research and Technology	
V	Support research and development of technologies that improve water management and reduce the impacts of climate change on water resources	• Fund research on new water-saving technologies and climate adaptation strategies. • Encourage partnerships between universities, research institutions, and private companies. • Promote the use of remote sensing and data analytics to monitor water resources and predict climate impacts.

VI	Policy Reforms and Governance Improvements	
	Update and enforce water policies that reflect sustainable development principles and address current challenges posed by climate change and water scarcity	• Revise water allocation policies to prioritize essential uses and promote efficiency. • Strengthen regulatory frameworks to prevent water pollution and over-extraction. • Promote transparency and accountability in water governance to ensure fair access and use

In this regard, it is advisable to accelerate the gradual transition to full digitalization of the water resources management and the use of innovative monitoring and management systems that allow for full process tracking from the water intake in the sources to the end consumers.

Gradual greening and environmentally friendly solutions are advisable to be widely applied in the implementation of the water projects, as well as during the work life period by the application of the harmless materials and technologies, with minimal risks of pollution and depletion of water resources and ecosystems.

An agreement on the education of water experts in specific fields in selected appropriate universities with the advance programs in the member countries and preparation of highly qualified specialists would be an important step for the better water management in the member countries in near future. Within the framework of joint projects, a team of experienced experts from the member countries can develop study curriculums for water-related specialties, including textbooks, teaching aids, booklets, bulletins and other visual materials for the overall raise of water use culture among various social groups, universities, schools and kindergartens.

Transboundary cooperation is very important for almost all member countries for harmonic intergovernmental relationship and joint actions for efficient water use and protection for all riparian countries. The management of the interstate hydraulic structures, built on the territory of one country, through which water is supplied to neighboring states, is also advisable to be organized by joint operation and maintenance.

The member countries of Kazakhstan, Kyrgyzstan, Turkmenistan and Uzbekistan are interconnected with the joint use of the main water basins in the region, therefore deepening of cooperation at transboundary level, implementation of the environmentally friendly joint projects to protect and rational use of water resources is advisable, which will to encourage the countries harmonize their national water programs.

Deepening transboundary cooperation with riparian countries is important for Azerbaijan, since the country locates in the lower reaches of the Kura-Araz basin and initiates the rational use and protection of the waters and ecosystems of the basin rivers, along the river from source to mouth by all riparian countries, including the expansion of mutually beneficial joint projects.

Türkiye, contributing enlargement of the transboundary cooperation in the Middle East region, with the participation of Iraq, Syria, Jordan, Lebanon and Iran, this process also is advisable to be intensified for the benefit of all involved countries.

Azerbaijan, Kazakhstan and Turkmenistan are recommended to make joint efforts to accelerate and strengthen cooperation to protect the Caspian Sea as a unique water body. An important step could be the establishment of the international joint research center with the participation of all involved five countries, including Russia and Iran. The program for the planting of green belt areas with salt-tolerant crops may prevent desertification and protect the biodiversity of Caspian Sea coastal areas due to the lowering of the sea water level.

Enlargement of the activities and implementation of the targeted projects coordinated by the International Fund for Saving the Aral Sea is advisable, which will support integrated use of water resources and environmental safety of the surrounded territories.

Special Water Committee within the Organization of Turkic States is recommended to be established from the key experts of member countries for coordination of the joint cooperation activities, organization of the periodic thematic discussions, draft proposals and recommendations for the member countries on the innovative water management tools and technologies, establishment of the joint water data exchange system, elaboration of the draft documents on unified regional policies, beneficial for the all member countries.

It is also essential to deepen cooperation with the worldwide key water institutions and international organizations, reputable experienced NGOs for better water management and their close attraction in proffering solutions to the regional water problems within the international rules and treaties.

Based on the above analyses, from a sustainable development perspective, addressing water resource management and cooperation in Turkic countries under climate change and water scarcity requires a multifaceted approach that balances environmental, economic, and social needs:

By implementing the highlighted strategies above, Turkic countries can better manage their water resources in the face of climate change, ensuring long-term sustainability and resilience of the national economies.

Thus, *the future well-being of the members of the Organization of Turkic States* will largely depend on how flexibly they respond, individually and jointly, to rapidly changing environmental, social and economic conditions, seeking, finding and developing mutually beneficial cooperation in the management and use of water resources, which is the driving force behind the development of national economies, local and regional well-being and prosperity in the member countries.

References

1. ADB (2021). ADB Regional Technical Assistance TA-9977 Central Asia Regional Economic Cooperation (CAREC): Developing the Water Pillar. https://www.carecprogram.org/ uploads/NFP_Session1.5_CAREC_Water_Pillar_Scoping_Report_20211012_EN.pdf;

2. Bayram, H., & Öztürk, A. B. (2021). Global climate change, desertification, and its consequences in Türkiye and the Middle East. Climate change and global public health, 445-458.

3. Broka, S., Giertz, Å., Christensen, G., Rasmussen, D., Morgounov, A., Fileccia, T., & Rubaiza, R. (2016). Kazakhstan agricultural sector risk assessment. World Bank Group Report Number 103076-KZ. https://documents.worldbank.org/en/publication/documents-reports/docum entdetail /422491467991944802/kazakhstan-agricultural-sector-risk-assessment;

4. CANEECCA (2023). The water crisis in Central Asia – how to find solutions? https://caneecca.org/en/the-water-crisis-in-central-asia-how-to-find-solutions/;

5. Capar G. (2019). Water resources management and climate change (Su kaynaklari yönetimi ve iklim değişikliği). İklim Değişikliği Eğitim Modülleri Serisi 8.

6. Chathuranika, I., Khaniya, B., Neupane, K., Rustamjonovich, K. M., & Rathnayake, U. (2022). Implementation of water-saving agro-technologies and irrigation methods in agriculture of Uzbekistan on a large scale as an urgent issue. Sustainable Water Resources Management, 8(5), 155.

7. Dzhumagulov, A. M., Baigazieva, D. M., & Eshmuradova, N. D. (2024). Transboundary water management in Kyrgyzstan: International law aspects. In BIO Web of Conferences (Vol. 107, p. 04003). EDP Sciences. https://doi.org/10.1051/bioconf/202410704003;

8. Farinotti, D., Longuevergne, L., Moholdt, G., Duethmann, D., Mölg, T., Bolch, T., ... & Güntner, A. (2015). Substantial glacier mass loss in the Tien Shan over the past 50 years. Nature Geoscience, 8(9), 716-722.

9. Giritlioglu, S., & Tsoy, N. (2024). Water security and regional stability in central asia: the case of Uzbekistan and Afghanistan. Eurasian Research Journal, 6(2), 113-137. https://dergipark.org.tr/en/download/article-file/3899561;

10. GoA (2024). National Strategy on Efficient Use of Water Resources. Order of the President of the Republic of Azerbaijan dated 10 October 2024. https://static.president.az/upload/Files/2024/10/11/3579828d4b3fb5cd36b497304e510793_1179943.pdf

11. Government of Kazakhstan (2024). Concept of development of water resources management system of the Republic of Kazakhstan for 2024-2030. Resolution of the Government of the Republic of Kazakhstan dated February 5, 2024 No. 66. https://adilet.zan.kz/rus/docs/P2400000066#z12;

12. Government of Kyrgyzstan (2023). National Water Strategy of the Kyrgyz Republic until 2040. Centralized database of legal information of the Kyrgyz Republic. https://cbd.minjust.gov.kg/ 434906/edition/1230660/ru;

13. Government of Turkmenistan (2021). Agreement between the Government of the Republic of Uzbekistan and the Government of Turkmenistan on the Joint Uzbek-Turkmen Intergovernmental Commission on Water Management Issues. https://www.fao.org/faolex/results/details/en/c/LEX-FAOC215058/

14. Ismayılov, R., & Suleymanov, F. (2024). Water resilience under climate change in Azerbaijan. Geojournal of Tourism and Geosites, 53(2), 677-686. https://gtg.webhost.uoradea.ro/PDF/GTG-2-2024/gtg.53231-1243.pdf

15. Imamaliyev M. (2023). Concept of the Water Resources Management Program of the Republic of Kazakhstan for 2020-2030. https://unece.org/environment/documents/2023/08/reports/concept-water-resources-management-program-republic;

16. Janusz-Pawletta, B., & Gubaidullina, M. (2015). Transboundary water management in Central Asia. Legal framework to strengthen interstate cooperation and increase regional security. Cahiers d'Asie centrale, (25), 195-215. https://journals.openedition.org/asiecentrale/3180?lang=en;

17. Jalilova, M. (2024). National Water Resources Management Strategies of Central Asian Countries and Their Transnational Effects (Национальные стратегии управления водными ресурсами стран Центральной Азии и их транснациональные эффекты). Society and Innovation, 5(6), 224-236. https://doi.org/10.47689/2181-1415-vol5-iss6-pp224-236;

18. Kakabayev, A., Yessenzholov, B., Khussainov, A., Rodrigo-Ilarri, J., Rodrigo-Clavero, M. E., Kyzdarbekova, G., & Dankina, G. (2023). The Impact of Climate Change on the Water Systems of the Yesil River Basin in Northern Kazakhstan. Sustainability, 15(22), 15745;

19. Kalashnikova, O., Niyazov, J., Nurbatsina, A., Kodirov, S., Radchenko, Y., & Kretova, Z. (2023). Kyrgyz transboundary rivers' runoff assessment (Syr-darya and Amu-darya river basins) in climate change scenarios. Central Asian J Water Res, 9, 59-88;

20. Kibaroğlu, A. (2022). Türkiye's Water Security Policy. Insight Türkiye, 24(2), 69-88;

21. Liang, L., Zhang, F., & Qin, K. (2021). Assessing the vulnerability of agricultural systems to drought in Kyrgyzstan. Water, 13(21), 3117. https://www.mdpi.com/2073-4441/13/21/3117;

22. Madaliev, M. M., Bilanova, A. B., Namatbekova, N. M., Nuraliev, N. A., & Alim, A. A. (2024). The role of state institutions of Kyrgyzstan in the formation of water resources management policy. In BIO Web of Conferences (Vol. 107, p. 04001). EDP Sciences. https://www.bio-conferences.org/articles/bioconf/pdf/2024/26/bioconf_yrc2024_0400.pdf;

23. Mayar, M. A., Hamidov, A., Akramkhanov, A., & Helming, K. (2024). Consideration of the Environment in Water-Energy-Food Nexus Research in the Aral Sea Basin. Water 2024, 16, 658;

24. Musabay Baki, P. (2022). Turkic World Vision–2040: A Step Forward for the Resilience of Turkic Cooperation. PERCEPTIONS: Journal of International Affairs, 27(1), 26-52. https://dergipark.org.tr/en/pub/perception/issue/71446/1149279;

25. Melikoglu, M. (2023). Hydropower in Türkiye: Analysis in the view of Vision 2023. Renewable and Sustainable Energy Reviews, 25 (2013), 503-510.

26. Myratberdiev, Y., & Jumadurdyev, T. (2023). Turkmen Lake "Altyn Asyr" in Turkmenistan - a Grandiose Hydrotechnical Project (Туркменское озеро «Алтын Асыр» в Туркменистане–грандиозный гидротехнический проект). https://rep.bntu.by/bitstream/handle/data/135915/324-330.pdf?sequence=1;

27. National Statistical Committee of the Kyrgyz Republic (2022). Kyrgyz Republic: Share of economic sectors in the gross domestic product (GDP) from 2012 to 2022 https://www.statista.com/statistics/528614/share-of-economic-sectors-in-the-gdp-in-kyrgyz-republic/;

28. OECD (2020). Overview of the use and management of water resources in Central Asia. A discussion document https://issuu.com/oecd.publishing/docs/final_report_eng_issuu;

29. Ozenbayeva, A., Yerezhepkyzy, R., Yessetova, S., Jangabulova, A., & Beissenbayeva, M. (2022). Legal regulation of transboundary water resources of the republic of Kazakhstan. Environmental Development, 44, 100781. https://www.sciencedirect.com/science/article/abs/pii/ S2211464522000835;

30. Pouya, S., & Turkoglu, H. (2020). Evaluation of the water resource plans in Türkiye based on sustainable water management principles. Sustainable Water Resources Management, 6(5), 91;

31. Rzayev M. (2023). Measures for rational use of water resources in irrigation zones of Azerbaijan in the context of climate change (Меры по рациональному использованию водных ресурсов в зонах орошения Азербайджана в условиях изменения климата). Мелиорация, 4 (106), 68-72;

32. Sokolov V. (2022). Uzbekistan's National Strategy on Water Management and development of irrigation 2021-2023. https://www.gwp.org/globalassets/global/gwp-cacena_files/en/pdf/ uzbekistan-water-strategy-2023-sokolov.pdf;

33. Soliev, I., & Theesfeld, I. (2020). Benefit sharing for solving transboundary commons dilemma in Central Asia. International Journal of the Commons, 14(1), 61-77;

34. State Statistic Committee of Azerbaijan (2024). Gross Domestic Product in 2023. https://stat.gov.az/news/index.php?lang=az&id=5754;

35. Statista (2024). Share of economic sectors in the GDP in Kazakhstan 2022. https://www.statista.com/statistics/436156/share-of-economic-sectors-in-the-gdp-in-kazakhstan/;

36. Taganova, J., Cholico Santoyo, Z., Mattur, R., Best, J., & Shabanova, A. (2022). Should Turkmenistan use the Caspian Sea to quench its thirst. Central Asia Program (CAP). https://centralasiaprogram.org/turkmenistan-caspian-sea-quench-thirst/;

37. The Global Economy, 2023. Turkmenistan. Share of agriculture. https://www.theglobaleconomy.com/Turkmenistan/Share_of_agriculture/;

38. Trading Economies (2023). Türkiye-Agriculture, Value Added % of GDP. https://tradingeconomics.com/Türkiye/agriculture-value-added-percent-of-gdp-wb-data.html;

39. Tursunova, A., Medeu, A., Alimkulov, S., Saparova, A., & Baspakova, G. (2022). Water resources of Kazakhstan in conditions of uncertainty. Journal of Water and Land Development, (54), 138-149;

40. UN, 2024. Sustainable development goals. Retrieved from: https://www.un.org / sustainabledevelopment/water-and-sanitation

41. Uzbekistan - Country Commercial Guide (2023). Agricultural Sectors https://www.trade.gov/country-commercial-guides/uzbekistan-agricultural-sectors;

42. WB & ADB (2021). Climate Risk Country Profile: Azerbaijan. World Bank. https://www.adb.org/sites/default/files/publication/707466/climate-risk-country-profile-azerbaijan.pdf

43. WB& ADB (2021). Climate Risk Country Profile: Turkmenistan. World Bnnk. https://climateknowledgeportal.worldbank.org/sites/default/files/2021-06/15837-Turkmenistan%20 Country%20 Profile-WEB_0.pdf;

44. Worldometer Statistical Database (2024). Water Use by Country. https://www.worldometers.info/water/;

45. Yessymkhanova, Z., Niyazbekova, S., Dauletkhanova, Z., Satenova, D., Zhumasseitova, S., Kadyraliev, A. T., & Dzholdoshev, N. (2021, December). Water resources management in Kazakhstan in conditions of their shortage. In IOP Conference Series: Earth and Environmental Science (Vol. 937, No. 3, p. 032012). IOP Publishing. https://iopscience.iop.org/ article/10.1088/1755-1315/937/3/032012/pdf;

AZERBAIJAN

LIST OF ABBREVIATIONS

OTS	Organization of the Turkic States
AQUASTAT FAO	Statistical Database for Water
AAWM JSC	Azerbaijan Amelioration and Water Management JSC
ASWRA	Azerbaijan State Water Resources Agency
EAIS	Electronic Agriculture Information System
EWMIS	Electronic Water Management Information System
O&M	Operation and Maintenance
CAP	Common Agricultural Policy
CBD	Convention on Biological Diversity
SADC	State Agricultural Development Centers
ELCS	Electronic Land Cadaster Registration System
FAO UN	Food and Agriculture Organization
FAOSTAT FAO	Statistical Database
FMIS	Farm Management Information System
FSA	Food Safety Agency of the Republic of Azerbaijan
MoA	Ministry of Agriculture
MoE	Ministry of Economy
MENR	Ministry of Ecology and Natural Resources
NMC	National Hydrometeorology Center
NWS	National Strategy on Efficient Use of Water Resources
SCADA	Supervisory Control and Data Acquisition
SADC	State Agricultural Development Centers
TC	Tariff Council of the Republic of Azerbaijan
SSC	State Statistics Committee
SSPI	State Service on the Property Issues
UNFCCC	United Nations Framework Convention on Climate Change
UNCCD	United Nation Convention to Combat Desertification
WASOA	Water Amelioration Systems Operation Administration
WFD	Water Framework Directive
WUU	Water User Union

EXECUTIVE SUMMARY

The Republic of Azerbaijan, situated at the crossroads of Eastern Europe and Western Asia, is bordered by the Caspian Sea and surrounded by diverse mountain ranges and climatic zones. This geographical complexity results in a varied distribution of water resources.

The natural water resources of the country are estimated to be scarce in comparison with the other South Caucasus countries, and covers only 15% of the water resources of the entire region compared to other countries of the South Caucasus. Azerbaijan's water resources are largely influenced by transboundary flows, with about 70% of its water coming from neighboring countries. The country has internal rivers, but transboundary Kura, Araz, Samur Rivers are most significant for the country and region, entering from the upstream countries. This dependence makes Azerbaijan's water supply vulnerable to changes in upstream water management. In Azerbaijan, the area of the 10 lakes is larger than 10 km^2. The largest one is Sarisu Lake located in Kura-Araz lowland with a surface area is 65.7 km^2 and the capacity is $59.1x10^6$ m^3. The volume of currently used groundwater is 26% of the approved resources. Mingachevir Reservoir is the largest reservoir and hydro junction in the country, which combines energy, irrigation, water supply, fisheries, shipping and flood control. The annual water balance data of the recent year's data reflects a steady increase in water usage, with significant water consumption by the agricultural sector due to its reliance on irrigation.

The eastern borders of Azerbaijan adjoin the Caspian Sea. The length of the Caspian Sea coastline is approximately 6,380 km, of which 825 km belongs to Azerbaijan.

Irrigated agriculture is concentrated mostly in the Kura-Araz lowland, which faces high temperatures and a deficit of soil natural moisture during crop growing period. The irrigation water infrastructure in the country was developed rapidly for the urgent expansion of agricultural production, to comply targeted state plans in Soviet ruled period and most irrigation networks represented a system of earth canals with the application of the traditional irrigation methods in the fields. After the 1990s land reforms, and free land distribution to the peasants, due to the fragmentation of large fields, a partial violation of the technological integrity of irrigation systems occurred. From 2000-2022, the water losses in transportation increased by 8.5%. Over the past period, the state's main attention has been drawn to maintaining the operational capabilities of the existing infrastructure. Therefore, acceleration of the enlargement of the new technological applications in irrigation can eliminate the main reasons of the occurrence of unproductive losses, in water supply and irrigation.

During the last fifteen years, the piped water supply countrywide went up from 40% to 70%. Providing reliable drinking water to the areas most affected by climate change is a government priority. Similarly, during last three years, the industrial water use in the country increased by 41.3 %, due to the rapid development of industrial zones in the regions and intensive rehabilitation works in released territories from Armenian occupation; Karabakh and Eastern Zangazur economic regions of Azerbaijan.

Since gaining independence, Azerbaijan has developed a comprehensive legal and regulatory framework to manage its water sector effectively, adapting to the evolving market economy and changing water use patterns. Key legislative documents are Water Code (1997), Law on Amelioration and Irrigation (1996), Law on Water Supply and Sanitation (1999), Rules on Water Use (2014), Law on Hydraulic Structures (2002), Paid Water Services Rules (2006 and 2022) and other legislative documents. According to the Presidential Order in 2020, a high-ranking state commission, (Water Commission) was established for the integrated and efficient management of water resources in the country, which is chaired by the Deputy Prime Minister of the Republic of Azerbaijan.

The country joined "The Convention on Wetlands of International Importance", especially as "Waterfowl Habitat" (2000), "The Convention on the Protection and Use of transboundary Watercourses and International Lakes" (2002), "Framework Convention for the Protection of the Marine Environment of the Caspian Sea" (2006) and others.

The institutional structure of water sector management has been subject to change, and adaptation to new conditions aimed at improving the quality of services and sustainable use and management of water resources. The primary recent development is the establishment of the Azerbaijan State Water Resources Agency (ASWRA) in 2023, which is the central body for implementation of the unified state policy in the water sector, manages all aspects of water resources, including safety, facility operation, and compliance with regulations. The Ministry of Ecology and Natural Resources, oversees hydrogeology investigations, environmental protection, and water cadastre maintenance. Ministry of Agriculture supports farmers with technical and financial assistance, and collaborates with ASWRA to manage irrigation plans and schedules. "Azerenergy" JSC, involves in hydropower generation and water resource management, through reservoir regulation. Ministry of Health monitors drinking water quality and oversees sanitation regulations. The Water Commission coordinates water resource management, improves efficiency, and ensures sectoral cooperation. The Tariff Council regulates and sets tariffs for water services. Ministry of Economy and Ministry of Finance support the development and funding of water infrastructure and manage fiscal policies related to the water sector. Ministry of Emergency Situations handles policy and regulations concerning emergency situations related to water bodies. Besides the related water governance organizations, various research institutes and universities conduct studies on water resources, hydrology, water quality, and environmental impact assessment, providing expertise and knowledge to support water management efforts.

The snow measurement results in recent years evidently show reduction of the snow in all country river basins. The dynamics of change in the Kura River flows makes it difficult to plan water connected activities, including irrigation, water supply and power generation. On average, precipitation levels have declined by 9.9 % over the past decade. The average annual temperature increase from 1991 to 2001 is more than three times as high as the annual increase observed between 1961 and 1990. The sensitive areas of special attention in terms of water security are the Absheron Peninsula and the Kura-Araks Lowland. The Kura-Araz lowland is an important agricultural region, an area heavily dependent on irrigation. The area is affected by on-going salinization and desertification. The water supply and sanitation services in rural areas are limited. The increase in the ability to respond to natural disasters or risks, caused by climate change in the lowland is important, as the area is vulnerable to floods and droughts, approximately, 15% of the population lives at risk of flooding. Based on the model estimations, by 2100 river flows is expected to fall by approximately 26–35%. In the last 30 years, water resources reduced in Azerbaijan by 15% and this negative tendency is going on in the country. Overall, during transportation, water losses are on average 30% from the water taken from the natural sources. On-farm irrigation systems are mainly open type earthen canals' networks and irrigation is traditionally carried out mainly by surface irrigation methods (furrows, strips) in the fields. The share of canals with the earthen bed is 75% from the total operated canals. The land area covered by the drainage system is 610.7x10^3 ha.

The structure of the crop pattern is formed historically, considering the characteristics of natural and economic conditions and market demand. The main exports in 2022 was fresh fruit (378,554 tons), vegetables (169,008 tons), potatoes (78,301 tons), tea (1,780 tons), cotton fiber (75,070 tons) among others.

To improve water accounting system, in recent years, digitalization in water and agriculture sectors, through the establishment of the Electronic Water Management Information System (2021), and Electronic Agriculture Information System (2019) made it possible to obtain precise data, provide more efficient use and distribution of the irrigation water among the water users.

After gaining independence in 1991, the country has been putting huge investment into the water supply and sanitation sector. Currently, the centralized water supply covered by services in urban areas (93.8%), prevails in comparison with the rural places (32.8%). The municipal water consumption is estimated at 329x10^6 m^3/year.

Investments in water infrastructure, such as dams, reservoirs, and irrigation systems, are part of the government's efforts to improve water availability and efficiency. Given that climate change may also negatively impact groundwater resources, the role of stormwater and desalinated water becomes more important. The adopted Action Plan (2020) contains a set of measures, including construction of ten reservoirs as well as rehabilitation of hydraulic structures, irrigation canals and collectors.

As a result of the actions taken, Azerbaijan has made progress on the SDGs, including in the line of SDG6 target for clean water and sanitation. Generally, Azerbaijan was ranked 54th among 166 countries in the UN Sustainable Development Report for 2020, achieving 72.6 points out of 100 for the "Sustainable Development Goals Index".

Currently, applied water tariffs for the various consumers differ depending on the purpose of the water use. Water supply tariff is in the region is 0.35USD/ m^3, in Baku, Sumgait and other big cities-0.41-0.7 USD/m^3. Irrigation water fees provided to the Water Users Unions is 0.29 USD/10^3m^3, for watering of pastures- 0.24 USD/ha, which demonstrates high subsidizing by the government. During the last two decades, Azerbaijan has invested more than $3 billion on development of the water economy infrastructure, including irrigation canals, dams, water supply and wastewater facilities. The international financial institutions are also involved in the implementation of projects in the water sector.

The great return to the territories freed from Armenian occupation has been identified as one of the five main national priorities of Azerbaijan up to 2030. During the occupation period, the water management and reclamation infrastructure was seriously damaged. In addition to the complete destruction of the residential settlements including 9 cities, the 9 water reservoirs, 2 hydro-junctions, 7 water storages, 6,426 km of irrigation network, 330 km of collector-drainage network, 8,003 hydraulic structures, 88 pumping stations and 1,429 sub-artesian wells, as well as, 125,800 hectares of cultivated land has become completely unusable. Currently, rehabilitation and restoration of the water facilities in the released territories has been going through implementation, under the State Program on the "Great Return of the Liberated territories of the Republic of Azerbaijan."

The increase in population (10.2 million inhabitants in 2024) and future economic development will require more water for the different consumers, including agriculture, municipal water supply and sanitation, industry and hydropower and others. The government has recently initiated the pilot project for drinking water production through desalination of sea water, and currently, the project implementation is going on.

To prevent water losses, more sustainable supply of irrigation water, improves the lands ameliorative condition and the ecological state of the surrounding territories. The government recently made decisions on a complete reconstruction of the main Karabakh and Shirvan irrigation canals.

In Azerbaijan, systematic monitoring of surface water pollution has been carried out since 1966. Currently, these observations cover 44 water bodies, including 30 rivers, 9 lakes, 4 reservoirs. In both Kura and Araz main transboundary rivers, operational monitoring was organized based on the guidelines on "Monitoring and Evaluation of Transboundary Watercourses and International Lakes" developed by a team of qualified UNECE experts.

The water resources of Azerbaijan have been exposed to the significant changes not only in quantity, but also quality due to the on-going temperature raise and recent climate changes. In addition, from upstream countries, the flowing out untreated water leads to pollution of the Kura River basin, worsening water quality before entering the country. In Georgia, for many years, industrial waste waters flowed into the River Kura, containing about 70 different substances and toxicants among them. In the Okhchuchay River in Armenia because of wastewater drainage of mining areas, heavy metal concentrations significantly increased, and the river lost ability to provide ecosystem services. Pollution in the Kura and Araz Rivers downstream, the Mingachevir reservoir mainly originated from untreated sewage, organic-chlorine pesticides and high sediment loads form current irrigation practices.

The future protection of the basin water resources required establishing constructive cooperation between the riparian transboundary countries; Azerbaijan and Georgia drafted a joint action plan for the protection of the Kura River Basin and sustainable management of water resources. The Caspian Complex Ecological Monitoring

Department of MENR provides regular monitoring in the sea beach areas and conducts chemical, biological, ecotoxicological, microbiological examinations, defining all kind of pollutions and takes measures.

In the near future, Azerbaijan's water security platform, shall cover preparation of the Drought Management plan; Reservoir Safety and Flood Risk Management; Modernization of water management systems; Soil Salinity Management to prevent degradation of land and water resources; Irrigation Modernization by application of the advanced technologies; Water Supply and Sanitation Services Improvement for expansion of drinking water treatment and sanitation services.

The adopted in late 2024 National Water Strategy is a strategic document that covers all aspects of water management in the coming years, the implementation of which is aimed to contribute formation of a healthy attitude towards water resources in society, ensuring their careful consumption, protecting the environment, mitigating the effects of climate change and satisfying the needs of water users, thus accelerating the country's development. The document contains comprehensive Action Plan. The adopted document contains Actiion Plan for Implementation of the NWS during 2024-2027 with the five priorities, which includes assessment, efficient management, usage of water resources, including in Karabakh and East Zangezur economic regions as well as water security measures such as transboundary water management, protection of water bodies and others. The approval of the NWS marks a significant step in Azerbaijan's efforts to secure its water future amid growing concerns over water scarcity and climate change impacts.

Azerbaijan is going to host COP29 in 2024 which will facilitate international cooperation on climate-related issues, including in the field of protection, use and management of water resources. The participation of the representatives from all relevant stakeholders, governments, international organizations, NGOs and the private sector, will help focus on the larger issues of climate change and its impact on the quantity and quality of water resources in the different regions.

In summary, addressing Azerbaijan's future water needs will require a comprehensive approach involving infrastructure upgrades, application of the efficient water management tools, international cooperation, and environmental protection efforts. Continued targeted investments, improved management, stakeholders' and users' attitude to water is crucial for sustaining water availability and quality in the face of growing demand and environmental challenges.

CHAPTER 1. WATER AVAILABILITY, ABSTRACTION, AND WATER DELIVERY

1.1. Available water resources. Water balance

Azerbaijan is one of the countries of the South Caucasus, located at the junction of Eastern Europe and Western Asia, bordered by the Caspian Sea in the east, Russia in the north, Georgia in the northwest, Armenia in the west and Iran in the south.

The climate of Azerbaijan is very diverse. Nine out of eleven existing climate zones are present in Azerbaijan. The country is surrounded by both the Greater Caucasus and Lesser Caucasus mountains. The complexity of the landscape causes the uneven formation of climatic zones and sets up vertical climatic zones. Thus, the diversity of the country's geography, which is associated with the presence of mountains, plains, and coastal areas of the Caspian Sea, play an important role in the formation of the country's landscape, climate and subsequently to the amount and distribution of water resources in different water sources located along the country (Mamedov&Abduyev,2018).

The natural water resources of the country are estimated as scarce and covers only 15% of the water resources of the entire region, compared to other countries of the South Caucasus (Verdiyev,2024), primarily originating from the country's geographical location and climate characteristics. According to the estimations, Azerbaijan's annual water resources per capita are 2 times lower than Armenia's and 7 times lower than Georgia's (Reed, 2022). The local water resources per square kilometer in the country is estimated at $119x10^3m^3$, these indicators in Georgia and Armenia are $769x10^3m^3$ and $218.5x10^3m^3$ respectively (Imanov, 2016).

In general, the density of the river network is estimated at 0.36 km/km^2 (UNCCD, 2020; MENR, 2024.1). There are total, 8,359 rivers in Azerbaijan, from which the length of Kura and Araz Rivers are more than 500 km. Another 22 rivers have a length of 101-500 km, 40 rivers -51-100 km and 107 are 26-50 km length. Distribution of the rivers by the basins are as follow:

Kura River's own basin (left and right branches of the Kura River) -5,141 rivers;

Rivers of Araz Basin (left tributaries of Araz) -1,177 rivers;

Rivers flowing directly into the Caspian Sea -3,218 rivers.

Kura River is the main water flow in Caucasus area; it originates from eastern Türkiye, with the total length of 1,515 km and inflow to the Caspian Sea through Georgia and Azerbaijan. The length of the river, flowing throughout the territory of Azerbaijan is 906 km. The main tributaries are Alazan, Iori, Agrichay, Turianchay, Geokchay, Akstafa, Kurakchay, Terter, Xachinchay, Araz, Arpachay, Hakari, Khramchay Rivers. The river basin covers Türkiye, Georgia, Azerbaijan, Iran and Armenia with the total catchment area of 188,000 km^2. Elevation of the river at the source is 2,740 m and at the end point outflow to the Caspian Sea is 28m above sea level, for this reason the ecosystems of the basin is significantly diverse and include a wide range of landscapes, from semi-deserts, arid lands to the alpine grasslands. Share of Azerbaijan in the basin is -52.9 x $10^3 km^2$, Iran -40 x 103 km^2, Georgia -36.4 x 103 km^2, Armenia -29.8 x 103 km^2, Türkiye -28.9 x 10^3 km^2. The river water resources are formed seasonally from melting snow (36%), groundwater (30%), rain (20%), melting ice and snow in glaciers (14%). (Hasanov & Abbasov, 2020; Huseynov, 2017).

The recent studies have confirmed that, the share of melt water in the nutrition of the Kura River in the Mingachevir area is 52%, underground water 30% and rainwater 18%. The amount of underground water in the supply of the river tributaries is up to 40-60%, rainwater up to 20-30%, snow water up to 10-20%. (Ismayilov, 2021). Mainly, the river flow is formed in Georgia (37.7%), Armenia (23.4%) and Azerbaijan (21.5%), as well as 13.6% in Türkiye, 3.8% in Iran. More than 70% of river water is used for agriculture and others for hydropower generation, industry, domestic water use and forestry (Mamedov&Abduyev, 2018).

The Araz River is the largest tributary of the Kura River; it flows through the territories and borders of Türkiye, Iran, Azerbaijan, and Armenia. The total length is 1,072 km, from which 364 km flows directly in Türkiye. The catchment area is 101,9 km^2. The river source originates in Türkiye, 2,990 m above sea level, on the northern slope of the Bingildag Ridge. After the confluence of the Ahura Tributary, the Araz forms the state border of Armenia and Azerbaijan with Türkiye and Iran at approximately 600 *km* to the Bahramtepe hydraulic junction area. The end part of 80 km river flows through inland of Azerbaijan and merges with Kura River in the territory of Sabirabad town. In terms of water flow, it is the second river in Transcaucasia. According to the relief and flow characteristics, Araz is divided into mountain and flat parts. The Araz, in many places, flows as canyon-shaped streams to the mouth of the Nakhchivan River. The river flow is exuberant and liminal. In this part, Araz receives inflows from rivers Alincha, Ordubad, Mehri, Okchu and others on the left, Kotur, Kirsi and left tributaries on the right. After the mouth of the Hekeri River, Araz gradually rises to the plain and Kura-Araz Plain, the bed becomes a meander. Below the mouth of the Hakari River, the Araz is adjacent to Guruchay, Kondalanchay and others on the left, Selin, Karasu and left tributaries on the right. The active erosion process of the river in the mountainous areas is replaced by its accumulation on the plain. Araz feeds from a different source; including 38% snow, 18% rainwater and 44% other water flows. The average annual water discharge of Araks River, is 279 cubic meters per second, the flow volume is 8.8 billion cubic meters. By the hydro chemical characteristics, the river water belongs to hydro-carbonate-calcium type. The average mineralization during the low-water flow period is 560-880 mg/l and high-water flow period is 260-400 mg/l (Azerbaijan Geographical Society, 2024). (Figure1).

Figure 1. Schematic map of the Kura-Araz River basin

Source: EUWI,2024. Pilot River basins.

https://www.euwipluseast.eu/en/about/pilot-river-bassin/kura

The Samur River is the largest river in the north-east of Azerbaijan. In physical and geographical terms, the Samur basin is characterized by landscape contrasts - from the high-mountain glacial peaks of the Main Caucasus Range with elevations up to 4,466m Bazarduzu mount to the low-lying delta plain, a significant part of which is below the sea level up to -27 m. It is mainly fed by underground and glacial waters. The river starts from Dagestan and finally flows directly into the Caspian Sea. The length of the river is 213 km and catchment area is 4,990 km^2. About 80% of the basin area lies above 1500 m. The river plays an important role in the water supply of agricultural and industrial areas for the Republic of Dagestan and the Republic of Azerbaijan (Atayev, et al., 2021).

A total of 21 rivers in Azerbaijan are situated in the territory of four or five other countries and most of them belong to the basin of the Kura -Araz Rivers. Kura, Ganikh (Alazan), Gabirry (Iori), Khrami, Arpachay and other rivers flow, running through the territory of two or more countries, therefore they are trans-boundary rivers. Araz, Samur, Bolgarchay and other rivers flow running, belong to boundary rivers, dividing two countries.

Overall, the main transboundary and boundary rivers are presented in Table 1 below.

Table 1. Main transboundary and boundary rivers of Azerbaijan

The name of river	Length, km	Catchment area km^2	Average long term annual flow m^3/sec
Kur	1,515	188,000	402
Araz	1,072	101.9	279
Samur	213	4,990	64.8
Qanıx (Alazan)	391	12,080	108
Qabırrı (Iori)	320	4,800	15.6
Anaxatır (Khrami)	201	8,340	53.5
Arpaçay	126	2,630	11.5
Bolqarçay	163	2,170	2.06

The local mountain rivers are characterized by speedy flow run 3-6 m/s during the flood, and high average gradients in the range of 15-150 %. The rivers flowing from the southern slope of the Greater Caucasus are Balakenchay, Talachay, Kurmukchay, Kishchay, Turyanchay, Goychay, Girdimanchay and others, are Kura River left tributaries. Gobustan Rivers (Sumgayitchay, Pirsaat and others) flow directly into the Caspian Sea. Zeyemchay, Shamkirchay, Goshgarchay, Ganjachay, Kurekchay and others flowing from the northeastern slope of the Lesser Caucasus, as well as Khachinchay, Tartarchay, Gargarchay Rivers flowing from the Karabakh range, are the right tributaries of Kura River. The rivers flowing from the Zangezur range are Nakhchivanchay, Alinchachay and Gilanchay. The rivers flowing from the southwestern slope of the Lesser Caucasus are Hekarichay, Guruchay, Kondalanchay and others. The rivers are the left tributaries of the Araz River. The rivers of Lankaran area, Vilashchay, Lankaranchay, Tangeruchay, Astarachay and others flow directly into the Caspian Sea (NHC, 2024, 1).

In Azerbaijan, 450 lakes with a total area of 395 km^2 have been identified; the area of the ten lakes is larger than 10 km^2. The largest one is Sarisu Lake, located in Kura-Araz lowland with a surface area of 65.7 km^2 and the capacity is 59.1 million m^3. The surface area of Aggol is 56.2 km^2 and volume is 44.7 million m^3. Candargol with an area of 10.6 km^2 and volume of 51 million m^3 is located on the border with Georgia. In general, the total volume of the main lakes in the country is about 265 million m^3.

There are 136 reservoirs in the country with a total volume is 21,500 million m^3. Most of the reservoirs are seasonally regulated and used for irrigation. The Shamkir, Yenikend, Mingachevir, Varvara, Araz and Sarsang water reservoirs constructed on the Kura, Araz and Tartar rivers are complex water management facilities providing energy, irrigation, and water supply services.

Mingachevir reservoir is the largest reservoir and artificial water basin in the country. This is a hydro junction that combines energy, irrigation, water supply, fisheries, shipping and flood control. The reservoir is located in the middle course of the Kura River. Stream regulation is perennial. The structures of the hydro junction include; channel-type earthen dams, HPP, surface-type dewatering units, intake facilities of the Upper Shirvan and Upper Karabakh canals.

Since 1951, observations and geophysical studies have been carried out to study the hydrological regime of the reservoir, the condition of the aquifer, hydro- chemical and hydrobiological indicators of water.

According to its morphometric characteristics, the reservoir's water area is divided into 6 areas. The length of the reservoir along the river valley is 70 km, its width is 3 km near the dam, 18 km at the confluence of the Ganikh and Gabirri rivers, and its average width is 8.6 km. The length of the coastline is 24 km. The water maximum depth is 75m and averagely 26m. The annual amplitude change of the average water level is 6-8 m. (Musayev et al, 2009).

In general, according to the estimations, the regional exploitation reserves of underground water are approximately 9x109 m^3/year. Mineralization of the underground waters in the volume of 1,6x109 m^3/day is between 1-3 g/l. About 20 of the centralized underground aquifers are under operation. The volume of currently used groundwater is 26% of the approved resources. The 80% of abstracted groundwater is used for irrigation and technical purposes.

The estimated underground water resources vary in the different regions. (Table 2.)

Table 2. Location and estimated underground water resources

Region		Estimated m^3/day	Region		Estimated m^3/day
1	Greater Caucasus	1008.9	7	Karabakh-Mil foothill plain	7909.9
2	Absheron Peninsula	241.9	8	Mugan foothill plain	130.0
3	Samur-Devechi foothill plain	3470.7	9	Jabrail foothill plain	344.0
4	Kanikh-Eyrichay valley	3822.0	10	Lankaran foothill plain	209.0
5	Ganja foothill plain	4218.6	11	Nakhchivan foothill plain	902.2
6	Shirvan foothill plain	517.7	12	Small Caucasus foothill plain	982.3
Total:					**23764.3**

The total reserves of thermal and technical waters in the country are estimated at 419,093 m^3/day (MENR, 2024,1).

The Caspian Sea is the world's largest landlocked body of water and accounts for 44% of the world's lake waters. The eastern borders of Azerbaijan adjoin the Caspian Sea. Besides Azerbaijan, other Caspian states are Turkmenistan, Kazakhstan, Russia, and Iran. The water level in the sea is variable and sea average area is 370,000 km^2, length 1,200 km, with the width 204-466km. The length of the Caspian Sea coastline is approximately 6,380km, of which 825km belongs to Azerbaijan. The bottom of the Caspian Sea is divided into three areas by the elevation. The average depth of water in the smallest northern area is 6-27m, extending to the Mangystau Peninsula. The middle and southern areas are separated by the Absheron Peninsula. The southern area of the sea is deepest, the average depth is about 350m, and the maximum is up to 1,028 m. The Caspian Sea plays an important role in the economy of Azerbaijan. Along with tourism, resort business, and fishing, the country uses the sea rich hydrocarbon reserves for the benefit of the national economy (Czech, 2018; Abbasov et al, 2022,1].

1.2. Water balance

The water balance of the country is approved every year by the resolutions of the Cabinet of Ministries of the Republic of Azerbaijan. The main responsible public agencies for the water balance data collection and submission are ASWRA and MENR. Annual water economy balance of the country (Table 3) is annually composed to account available water resources, their consumption by the different consumers and outflows (CoM, 2023).

Table 3. Annual water economy balance of the Republic of Azerbaijan, 10^6 m^3

Indicators	Years		
	2020	2021	2022
The use of water resources (except for energy)	8,421.0	9,007.3	9,333.8
Energy	19,606.7	23,299.8	25,184.0
Drinking water supply	401.1	428.4	487.6
Raw water supply, including:	8,019.9	8,578.9	8,846.3
Irrigation	7,397.1	7,861.3	7,564.6
Industry	28.8	46.6	40.7
Fishery	71.7	64.1	75.0
Households	475.5	490.5	984.0
Other users	46.8	116.4	182.0
Losses	4,656.0	4,843.0	4,954.7
Not used water, including	9,562.2	10,749.3	10,424.9
Underground water	6,423.0	6,258.5	5,977.8
Others (rivers' inflow to the Caspian Sea)	3,139.2	4,490.8	4,447.1

Azerbaijan is a downstream country, therefore, as can be seen from Table 3, about 70% of the country's water is generated from inflows from neighboring countries, which is one of the main reasons that makes the country's water resources vulnerable from transboundary flows.

The water use structure shows that the main water user of water in the country is the agriculture sector due to the location of the main irrigated areas in the arid zone (Table 4).

Table 4. The water use distribution by the sectors

Indicators	Years		
	2020	2021	2022
The use of water resources (except for energy)	8,421.0	9,007.3	9,333.8
Energy	19,606.7	23,299.8	25,184.0
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Underground water	6,423.0	6,258.5	5,977.8
Others (rivers' inflow to the Caspian Sea)	3,139.2	4,490.8	4,447.1

The Table 4 evidently demonstrates that, irrigation water use has the tendency to be increased. Households' water consumption increase is also significant in 2022, in comparison with 2020; due to the taking of more control measures after establishment of Water Commission (WC) in 2020. Water balance data is planned to be specified more precisely in upcoming years by the establishment of the improved water accounting system in the country, within development of the EWMIS, which includes all water related information.

In general, an increase in the trend of water abstraction from the natural sources since 2000 is obvious (Table 5). Due to the population increase during 1990-2022, water consumed per capita decreased from 2,293 to 1,371 m^3. Although the area of irrigated lands is not enlarged significantly, irrigation water consumption remains high. Since 2020, there has been a moderate decrease in the water losses due to taken integrated measures to improve water accounting and water use control system (SSC, 2023:1).

Table 5. Structure of water use in the Republic of Azerbaijan

Indicators	2000	2010	2015	2020	2022
Water taken from natural sources	11110	11566	12285	12961	13841
Per capita, m^3/person	1397	1295	1289	1300	1371
Total water consumption, 10^9 m^3, including	6,588	7,715	8,567	9,693	10,528
Household and drinking, 10^6 m^3	449	405	323	319	329
Production, 10^9 m^3	2,316	1,742	2,117	2,073	2,449
Irrigation and agriculture, 10^9 m^3	3,819	5,497	6,057	7,252	7,992
Losses while transportation, 10^9 m^3	3,053	3,851	3,718	3,268	3,214
Total wastewater discharge, 10^9 m^3	4,106	6,037	5,575	4,759	5,083
Area of irrigated land, 10^6 ha	1,4260	1,4246	1,4345	1,4802	1,4849
Water consumption per hectare, m^3/ha	2678	3858	4222	4899	5382

For two decades, the country has been experiencing a trend of declining renewable freshwater resources (Figure 2)

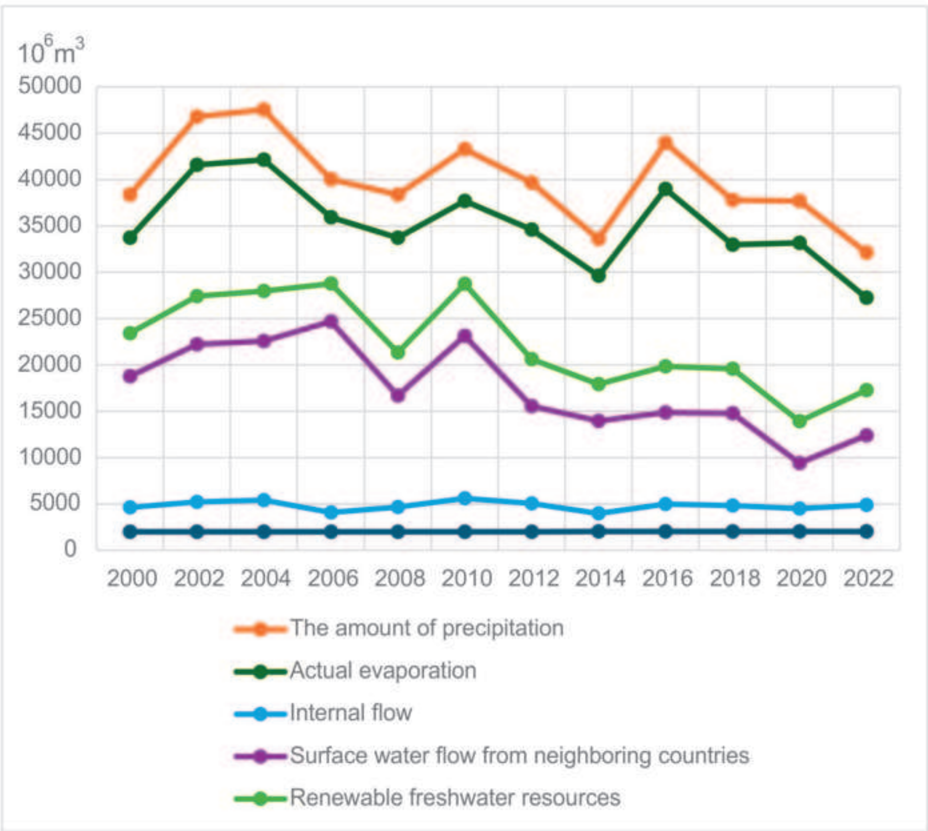


Figure 2. Renewable freshwater resources dynamics by years

The trend in reducing renewable freshwater resources is associated with rising temperatures, reduced surface water inflow and reduced precipitation (WB, & ADB, 2021).

1.3. Agricultural water use

The data of the water abstraction during the period of 2000-2022 demonstrates that water taken from the natural sources is increased from 11.11 to 13.84 x10^6m^3 or 24.6%. The water taken for irrigation increased from 3.819 x10^6 m^3 to 7.692 x10^6m^3. Irrigated agriculture is the main water consumer, which has particular importance for the national economy and rural welfare. Almost 90% of agricultural products are grown on irrigated lands. Due to the close highly mineralized groundwater table, irrigation is carried out by the application of drainage system for the soil salinity control.

Irrigated agriculture is concentrated mostly in the *Kura-Araz lowland*, located between the Greater and Lesser Caucasus, extending to the Caspian Sea in the eastern part of the country, which faces with the high temperatures and a deficit of soil natural moisture during the growing season, necessary for crop growing, so, agriculture is impossible without applying intensive irrigation. During the Soviet ruled period, the irrigation water infrastructure in the country was developed rapidly for the urgent expansion of agricultural production, to comply targeted state plans and most irrigation networks represented a system of earthen canals with the application of the traditional irrigation methods in the fields. After the 1990s, land reforms and free land distribution to the peasants, due to the fragmentation of large fields, a partial violation of the technological integrity of irrigation systems occurred, which expressed an increase in the density of inter-irrigation roads and field water distribution canals (Rzayev, 2007). During the period of 2000-2022, the water losses in transportation increased from the 3,053.4 to 3,313.5x10^6 m^3 or 8.5%. Over the past period, the state's main attention has been paid to maintaining the operational capabilities of the existing infrastructure.

The agricultural water consumption in the country tends to increase, although compared to 2010, the area of irrigated land increased by only 4.1%, and the consumption of irrigation water by 38%. The losses occurred due to outdated on-farm distribution networks, lack of proper hydraulic infrastructure, increased cotton growing area in the arid zones, which is characterized by the high evaporation from the field. If in 2010 the area under the cotton was 30,175 ha, it reached 100,295 ha by 2020s. In total, during the last two decades, water consumption per irrigated hectare has increased from 3,858 to 5,101m^3 (SSC, 2022, 1). Therefore, modernization of irrigation infrastructure is one of the main priorities of the country. Currently pivot irrigation system is applied in 56,000 ha irrigated area. It is aimed to increase up to 200 thousand hectares during the next five years, which is very important to save water resources (Tagiyev, 2023).

1.4. Water supply and sanitation, industrial water use

In 2023 the total water used for the municipal water supply is 310.18 x10^6m^3, of which the drinking water consumed by the population was 228.04 x 10^6m^3. Daily water consumption per capita was 62.1 l/sec. Currently, 67% of the served population consumers have access to the uninterrupted drinking water services, this rate in Baku city has reached 81.5%. In 2021, the rate of availability of households' indoor water lines was averagely 89.1%, including 99% in the city, 77.8% in rural areas. During the survey the 70.3 % households stated that drinking water supply is available 21-24 hours a day. In general, in 2021, water was provided to every household across the country, for an average of 19.8 hours per day (SSC, 2022: 2). Access to clean water is still challenging in most rural areas and improvement of this situation is the priority for the country.

During the last 15 years, the piped water supply countrywide went up from 40% to 70%. In most of secondary cities, there are now sophisticated (SCADA operated) water supply and wastewater & sanitation facilities that are fully in operational condition (WB, 2020). In 2022, the volume of the treated water was 207.8 x 10^6 m^3.

In total, in 2023, one drinking and five wastewater treatment plants, four water intake plants, six reverse osmosis plants, thirty reservoirs, twelve water and sewage pumping stations were built. At the same time, 1,037 km of drinking water and 179 km of wastewater lines were installed, and 26 sub-artesian wells were dug. As a result of the work done, more than 71,000 consumers were provided centralized drinking water services for the first time (ASWRA, 2024,1).

Water supply to areas most affected by climate change is a government focus. To improve the drinking water supply of the Neftchala town and villages in the region, a main water supply pipeline 40 km in length, a reservoir with a volume of 7500 m^3 were built in 2020. A new second main water supply pipeline system, 38 km length was built and put into operation in 2023 for the other settlements seriously suffering from drinking water supply (ASWRA, 2023:1).

During last three years, the industrial water use in the country increased by 41.3 %, which is in connection with the rapid development of industry zones in the regions and intensive rehabilitation works in released from Armenian occupation of Karabakh and Eastern Zangazur economic regions of Azerbaijan.

CHAPTER 2. WATER SECTOR INSTITUTIONAL FRAMEWORK

2.1. Existing legal framework

Since independence, the water sector regulatory framework in Azerbaijan has been developing for the improved water sector governance, and adequate water resource management under the new conditions, considering establishment market economy in the country and changing water use structure.

Water Code of Azerbaijan – regulates legal relations concerning the protection and use of water bodies in the country and details the obligations of the state with respect to the use and protection of water bodies in terms of monitoring and protection schemes as well as the supervision over the use and protection of water bodies, including irrigation. The Code provides for the development of schemes for the integrated use and protection of water resources, which is essentially a system, like the integrated management of water resources. Schemes for integrated use and protection of water resources shall be developed to determine water management measures and forecasting demand for water resources of the country, to ensure efficient use and protection of water bodies, as well as to prevent harmful effects of water and eliminate its negative consequences (GOA, 1998).

The Law on Amelioration and Irrigation determines the legal basis of the activities in the field of land reclamation and irrigation. This law identifies the state policy, including provision of irrigation water to land users and associations, implementation of public and regional programs, organization of financing, operation of state-owned land reclamation and irrigation systems, distribution of water, taken from water bodies. The Law stipulates regulation on the organization of registration and monitoring of irrigated and ameliorated lands, development of standards, norms, conducting state examination of the systems, research, and developing work control over the condition of irrigated and ameliorated lands, operation of amelioration and irrigation systems (GoA, 1996). This Law stipulates *Water User Unions (WUU)* for the management of the irrigation water at on-farm level. The main activities of WUUs have been identified (i) to receive water based on the contract concluded with local Irrigation System Administration for water delivery and purchase; (ii) O&M of irrigation and drainage systems in their own service area, and distribution of water according to the planned schedule; (iii) purchase, install and operate hydraulic structures, conduct land reclamation services; (iv) ensure thrifty usage of irrigation water, abide by water limits, protect water resources from pollution, usage of water structures as per their assignment, recording of water resources; (v) timely payment of fees for the supplied water, training of water users on progressive water usage, including advanced irrigation practices and technologies, and promotion of their application. A member of the WUU may be a person who has ownership over the land or has the right of land use for at least 3 years' duration. The main responsibilities of water users are to abide by the irrigation schedule, timely payment of irrigation water fees (IWFs), to permit O&M of hydraulic structures located on their plot, and to follow the instructions for operation of infrastructure. The higher management body of the WUU is the General Assembly, meeting at least once a year. The General Assembly has the exclusive right to define the main areas of WUU performance, adoption of rules and instructions, working plans and the irrigation water distribution schedule, approve the annual budget, water fees, payments for other services and penalties, selection and releasing of members of the Dispute Resolution Commission, and adoption, amendments, or liquidation of the WUU Charter. Management board has been given right to appoint an Executive Director, an accountant, farm engineer and other staff.

The Rules 'On the conditions of transfer of state amelioration and irrigation systems located in the WUUs service areas for long-term usage, and handover back to the government in the case of breach of these conditions', stipulates conditions of transferring of the state owned on-farm systems, located in the territory of the WUU, which shall be transferred to their operation within the period of 20 years under certain terms. According to the rules, The WUUs shall ensuring the operation and maintenance of the systems, carrying out amelioration measures, irrigation water supply, regular leaning of systems from sludge and weeds, timely payment of the cost of water supplied to the systems and the cost of electricity used during their operation. In the cases or upon expiration of the right to use the systems, the systems shall be handed over to the local irrigation department (GoA, 2005).

Law on Water Supply and Sanitation is the main legislative document providing regulation of relations in the area of water supply and sanitation services of the all consumers by supplying quality and necessary water and organization of the sewage discharges. In the Law, the rights related to the use of water, the principles of the provision of water supply and waste water discharge services, the functions of water supply and sewerage enterprises, the main terms of the state regulation in the field of water supply and sewage services, the quality of water supply, requirements for connecting to the water supply system, the consumers' duties in connection with the water supplied, rights and obligations on waste water discharge and the requirements of the law on other circumstances, arising from the provision of services, have been established. The law establishes that, while service delivery, drinking water supply to the consumers has *first priority,* it shall be in proper quality and quantity (GoA, 1999).

Rules on Water use are adopted in accordance with the above law, regulates the mutual relations between the water supply and sewage enterprise and the consumer in the field of water supply and sewage systems (water) use, and other related issues. The duties and rights of water supply and sewage enterprises and the consumers are determined under these Regulations, as well as the quality (composition and reliability of supply), volume, payment terms and other issues of the water supplied to consumers are specified in the purchase agreement concluded between them (GoA, 2014 :1).

Law "On the safety of hydraulic structures", which was adopted in 2002, regulates the relations related to the ensuring the safety of hydraulic structures, including during their design, construction, operation, reconstruction, restoration and conservation, determines the duties of state authorities, facility owners and the operators (GoA, 2002).

Resolution "On the rules of maintaining the state water cadastre", which was adopted initially in 1995 entrusted the maintenance of the state water cadastre of the Republic of Azerbaijan, defined responsible authorities to submit data on water use, and surface and groundwater. The rules indicate that in the state cadastre, the accounting of quantitative and qualitative indicators of water and also water use must be carried out according to a unified system throughout the entire country (GoA, 1995).

Since 1997, *paid water service* was put in force to achieve rational and economical water resources use. The latest rules for paid water services, which were adopted in

2006, have fixed the tariffs on the bases of used water volumes, in other words by consumed amount of irrigation water (GoA, 2006:1).

"Strategic Roadmap on production and processing of agricultural products in the Republic of Azerbaijan", adopted in 2016, defines integrated measures for improvement of the water use in agriculture, including improvement of the irrigation systems, application of the modern irrigation technologies to reduce inefficient water losses (GoA, 2016:1). The defined strategic goals in the document are: (i) institutional capacity building to ensure sustainability of food security, (ii) increasing the production potential of agricultural products along the value chain, (iii) facilitating access to finance, (iv) developing the marketing of production tools in the field of agriculture and improving the provision of services, (v) improving science, education and extension services in the field of agriculture, (vi) developing market infrastructure for agricultural products and facilitating producers' access to markets, (vii) protecting environment, ensuring sustainable use of natural resources and strengthening disaster management, (viii) increasing the efficiency of legal frameworks in the agrarian field and improving the business environment, and (ix) increasing employment in rural areas and the welfare of the population.

Regulations on "Electronic agriculture" information system developed since 2019, contains data on the water cadastre, irrigated lands, amelioration and irrigation networks, hydraulic structures, pumping stations, sub-artesian wells, soil salinization, as well as hydrographic network and water resources data shall be transmitted or entered (GoA, 2019:1).

The Regulation on "Electronic Water Management information system", contains data on the country's annual water balance, daily information on water resources at main water management facilities, including water levels in reservoirs, inflows and outflows from reservoirs and hydro- junctions, water intakes from rivers, pumping stations, their location, operation of sub-artesian and artesian wells and all other relevant data on the assessment, inventory and modeling of water resources. The separate modules are internal structure of the electronic information systems with the above data, electronic water map and crop irrigation schedules (GoA, 2021:1).

The Regulation "Compilation of water management balances by the country, water basins and administrative territorial units" was approved in 2019 determines the procedure for drawing up water management balances for the country, water basins and administrative territorial units. Every year, the Cabinet of Ministers is entrusted with the approval of the water management balance for the country, based on the actual expected and forecast indicators of the last three years (GoA, 2019:2).

New Rules on Paid Water use in the Republic of Azerbaijan, adopted in 2022, defines the conditions of paid use of water by all water users. The rules determine the conditions of the paid water use for water management facilities in the balance of the main water users. The standard forms of contracts and acts related to the supply of water to different consumers, water accounting and payment of fees for the services have also been approved (GoA,2022:1).

In recent years, due to the arisen situation with the water resource, the following legislative documents have been adopted:

– *Presidential Order "On the measures to ensure efficient use of water resources"* (2020). According to the order, a high-ranking WC (Water Commission) was established for the integrated and efficient management of water resources. In order to ensure the efficient use of water resources in the country, improve water resources management and coordinate activities in this area, the WC is mandated to analyze the current situation in the field of water resources usage and water management, increase the efficiency of water use, improve accounting and management, ensure operative coordination in the sector, and mobilize relevant government agencies, scientific organizations, qualified specialists and international experts to implement the above tasks. The WC is chaired by the Deputy Prime Minister of the Republic of Azerbaijan (GoA,2020,1).

– *Presidential Order "On additional measures to ensure the efficient use of water resources"* (2020), was adopted with the aim of increasing water resources in the country, especially water use from the internal rivers to improve the supply of drinking water and irrigation water to consumers. Under this document, "Action Plan for 2020-2022, on ensuring efficient use of water resources" is approved. This document includes all urgent water related activities that shall be realized during the upcoming period and defines roles of all stakeholders for the program realization under the coordination of the WC (GoA,2020:2).

The country has also adopted a set of environmental legislative documents that are not directly related to the water sector but are important over controlling the use and quality of water resources, their protection, as well as for the sector governance from an environmental requirements point of view (Table 6). (MENR,2024)

Table 6. The Adopted Main Environmental Laws in the Republic of Azerbaijan

The name of legislative document	Adoption date
Law on Fishery	1998
Law on Hydrometeorology	1998
Law about specially protected natural areas and objects	2000
Law on sanitary and Epidemiological Safety	1992
Low on Ecological Safety	1999
Law about environmental protection	1999

In relation to water resources, the international conventions to which the Republic of Azerbaijan has joined; plays an important role in their consideration in national water legislation. The water related Conventions are as below:

- The Convention on the Protection and Use of Transboundary Watercourses and International Lakes (Water Convention) – joining date 22.10.2002;
- Framework Convention for the Protection of the Marine Environment of the Caspian Sea – joining date 04.04.2006.
- The Convention on Wetlands of International Importance especially as Waterfowl Habitat – joining date 18.07.2000.

- Convention on the Conservation of European Wildlife and Natural Habitats-joining date 28.10.1999.

Thus, the normative and legislative framework of water sector governance continuously exposes to the improvements based on the developments and challenges arisen from the climate changes and its influence on the water resources. These changes support adopting updated integrated national and regional policies for better water governance, aimed at their protection and sustainable water supply for all.

2.2. Current institutional Structure

Since independence after the 1990s, the institutional structure of water sector management has been subject to change and adaptation to new conditions aimed at improving the quality of services and sustainable management of water resources. This improvement process is a continuously on-going process and reflects in the distribution of responsibilities among the related public bodies, involved in the water sector governance.

The Azerbaijan State Water Resources Agency (ASWRA) was established in 2023 on the basis of the liquidation of the State Water Resources Agency of the Ministry of Emergency Situations. According to the decision, “Azersu” OJC (providing water supply and sewerage services) and the “Amelioration and Water Management” OJC (providing irrigation and land reclamation services) were subordinated to the ASWRA structure. Thus, the ASWRA is the central executive body implementing a single state policy and regulation in the field of water intake, processing, transportation and water distribution, operation of state reclamation and irrigation systems, drinking water supply, rain and wastewater, treatment and discharge systems, organization of service provision, monitoring of surface and underground water resources, water and water management structures, hydraulic infrastructure and water supply systems in the country (GoA,2023:1).

Among others, the main activities of ASWRA includes to implement measures to ensure water safety in the country, safe operation and reliable protection of the water management facilities in the balance of the subordinate institutions, carry out state control over the protection and use of water bodies, soil salinity control of irrigated lands, prevention of water loss and ensure integrated management of water resources.

The responsibilities of the ASWRA are monitoring, maintaining the state water cadaster and recording of surface and groundwater at water bodies, hydroelectric facilities, water supply systems, control over the use of water bodies for their intended purpose, determining the regime of sanitary protection zones on water bodies, including sources of drinking water supply, taking measures to establish sanitary protection zones, flood control structures installation, master plans preparation for the integrated water resources use, losses prevention, drinking water quality improvement and others.

The agency has rights, among other activities, to cooperate with international organizations and relevant institutions, exchange of experience, make proposals to attract investments and conduct research works (GoA, 2023:2; ASWRA,2023:2).

The structure of the agency has been established to cover all the above responsibilities and enable the implementation of the unified and targeted water policy in the country. In addition to the central management administration, the following subordinated organizations had been established to manage all services and activities as defined by the regulation:

The State Control Service for the Use and Protection of Water under the ASWRA, carries out state control of compliance with the rules for the use of water bodies and their protection, water use limits, normative- legal acts for the sanitary-hygienic, ecological, hydrogeological, hydrological, and technological requirements, regime the territory of water protection zones, monitoring of water management facilities and other requirements of the water legislation.

The Regional Water Reclamation Service (RWRS) is a public legal entity, provides services for amelioration and irrigation, operation and protection of state reclamation and irrigation systems, operation of water resource facilities, as well as drinking, production, industrial and other water supply, rain and wastewater treatment and disposal services in regions of the country (except for the Baku, Sumgait, Ganja, Mingachevir and Shirvan cities).

The United Water Supply Service of Big Cities is a public legal entity provides drinking, production and other purposes water supply, processing and discharge of rainwater and wastewater services exclusively in Baku, Sumgayit, Ganja, Mingachevir and Shirvan cities;

The Water and Amelioration Scientific Research Institute is a public legal entity that carries out fundamental and applied research in the field of water and land reclamation and involved in conducting scientific research works for land improvements and restoration of their fertility, flood control, safety of the hydraulic structure, irrigation methods, water and soil tests and other activities, as well as postgraduate studies, preparation and conducting of the training for farmer and other related activities.

The Directorate of the On-going Construction Objects is a public legal entity established for the implementation of construction works, efficient management of funds allocated from the state budget and other sources for capital investment, as well as organization of the procurement for the construction and reconstruction of water management and reclamation facilities, water supply and sewage systems.

Design Institute of Water Reclamation Complex is the public legal entity for the design of water management and reclamation facilities, water supply, wastewater treatment and discharge systems (GoA,2023:2; GoA,2024:1).

WUUs are non-government organizations – operates on farm irrigation systems and on the bases of the agreement on water supply receives irrigation water from the *Rayon Water Amelioration Systems Operation Administration (WASOA)*, which is the local subdivision of the RWRS. Along with other conditions, the agreement must indicate water take point, devices on the canal, reservoir, pipeline, etc., upper, and lower limits of water supply, volume of water and delivery schedule distributed by the months. In accordance with the irrigation water supply, the annual contract agreement shall be concluded with the fixing of the crop pattern and water delivery schedule for the current agricultural year.

The WUUs have been established to represent the interests of water users, including farmers, households, and businesses. The WUU aims to promote sustainable water resources management and to improve the livelihoods of water users through capacity building, O&M of irrigation and drainage systems in their own service area and distribution of water, purchase, install and operate hydraulic structures, conduct land reclamation services, ensure thrifty usage of irrigation water, abide by water limits, protect water resources from pollution, usage of water structures as per their assignment, recording of water resources, and timely payment of fees for the supplied water, training of water users on progressive water usage procedures, including advanced irrigation practices and technologies, and promotion of their application (State Reclamation and Water Management Agency,2005).

WUUs coordinate farmers' activity with the local irrigation department and State Agriculture Development Center (SADC) Ministry of Agriculture for timely water and distribution among the farmers. In the process of their development since 1997, the number of WUUs was optimized from 582 to 373 for the whole country, which demonstrates gradual consolidation of service territories.

The Ministry of Ecology and Natural Resources is the central executive authority for the effective use and protection of the natural resources and environment in the country. Related to the water resources, in spite most of the responsibility was transferred by the establishment of ASWRA, the MENR is responsible for hydrogeology investigations, participate in effective use of biological resources of waters, including within country's owned Caspian Sea section, protection, use of nature, underground and surface natural resources, their restoration, activities related to waste, environmental impact assessment and strategic ecological assessment, observation of hydrometeorological processes and forecasting. According to the ministry's regulations, responsibilities include maintaining state registration, taking into account, the exploitation resources of surface and groundwater, as well as the state water cadaster together with the relevant state body, on the basis of monitoring of water; to carry out continuous control measures together with relevant agencies for the purpose of efficient and purposeful use of water bodies, protection of surface and groundwater from pollution; monitor water bodies together with relevant state bodies, to prepare schemes for integrated use and protection of water resources, participates in preparation of the water balances (MENR,2020).

The Ministry of Agriculture (MoA) is responsible for regulating the agriculture sector in the country. The ministry provides technical and financial support to farmers, including in the implementation of innovative technologies and the adoption of sustainable agricultural practices, participates in the monitoring and managing the use and protection of land, water resources, forests, wildlife, with a focus on ensuring the sustainable use and conservation of the natural resources for the benefit of the agricultural sector and overall society.

Regarding participation in the water resource management, the MoA through Rayon SADCs, support WUUs and farmers for delivery of the irrigation water to the fields and their fair distribution among the users. The Ministry cooperates with the ASWRA to support working out irrigation plans and define irrigation water demand at the beginning of each crop growing season and supports to keep irrigation schedules during the vegetation period (MoA,2005).

"Azerenergy" Joint Stock Company – is responsible for the hydropower generation and indirectly has a role in water resource management, as hydropower generation require necessary flows, therefore the company participate in regulation of water in reservoirs and rivers.

Ministry of Health – is responsible for the drinking water quality monitoring. The *Republic Hygiene and Epidemiology Center of the Ministry of Health (RHEC)* implements preventive measures for the sanitary control over the population's drinking water supply. According to the rules, design documents prepared prior to the reconstruction of drinking water supply systems, shall be submitted to RHES to check compliance with the sanitary and construction norms for approval.

The washing and disinfection of water reservoirs is carried out under the supervision of the Rayon Hygiene and Epidemiology Centers (RHEC). After the completion of cleaning stage, the water samples are taken for tests in the laboratories. Based on the test results, the reservoirs are allowed to be put into the operation. The monitoring of the quality and safety indicators of the water, for municipal supply from the network is conducted by taking water samples once a quarter, from stationary points determined in 61 city and district centers by the approved schedule. In Baku city, water samples are taken from stationary points once a month and tested according to their organoleptic, chemical, and bacteriological indicators in inter-regional laboratories. Thus, RHEC conducts systematic monitoring of the water quality throughout the country by conducting laboratory tests and reviews standards for drinking water, hygienic requirements, and quality control.

Water Commission (WC) is established by Decree of the President of Azerbaijan on 15 April, 2020. The head of the Commission is appointed Deputy Prime Minister and the members are ministers of Ecology and Natural Resources, Economy, Agriculture, Finance, Chairman of ASWRA, "Azerenergy" OJSC. The Commission has been established with the aim to ensure the efficient use of water resources, improve the water accounting, management, and coordination of the activities between the main water users. The WC is involved in analyzing the current situation of the water resources use and water economy management, take measures to increase efficiency of the water use, improve metering, manage and provide sectoral operational coordination. The WC was also tasked to ensure the involvement of relevant state bodies (institutions), scientific institutions (organizations), qualified specialists, as well as international experts for the implementation of the targeted tasks (GoA,2020:1). Additionally, the WC coordinates the activities of state bodies (institutions) during the implementation of the Action Plan and provides regular information to the government on the results of the implemented works. The WC will also ensure the cooperation with scientific institutions (organizations), specialists, non-governmental organizations, international experts and international financial institutions to ensure efficient and economical use of water resources in the fields of irrigation, drinking water supply, energy and industry (GoA,2020:2).

TC (Tarif Council) is a collegial executive body, implementing the state regulation of the prices (tariffs), service fees, collections where the state regulation is applied on, including tariffs for water use for different consumers. Its main responsibilities include developing and recommending tariff policies, monitoring market trends and making recommendations for changes in tariffs and pricing, conducting analysis to inform tariff and pricing decisions, ensuring that tariffs and prices are set in a manner that is transparent and fair to consumers and businesses. The Tariff Council works with other government agencies and stakeholders to ensure that tariffs and prices are set in a way that supports economic development.

The other government agencies such as the Ministry of Economy and Ministry of Finance are also involved in water sector management through their defined agency's functions. The *Ministry of Economy* plays a crucial role in supporting the development of the irrigation, water supply and sanitation system and in ensuring that the sector is developed and operated in a manner that supports the health, well-being, and sustainable development of the population. Vision 2030: National priorities for robust socio-economic development in Azerbaijan highlights high-quality ecological environment, including protected and efficient use of resources, balancing economic growth and environment safety, which considers land improvements, meet demand for quality water for the consumers by the efficient management and use of the water resources (GoA,2021:2).

The Ministry of Finance manages public funds, including allocated funds for the implementation of the targeted projects in the water sector.

The Ministry of Emergency Situations among other functions is responsible for development and implementation of state policy and regulation in the areas of human safety, provision, prevention and elimination of the consequences of emergency situations in water bodies.

There are also NGOs which participate in the public hearing while initiating important water projects, including construction of reservoirs, dams and other hydraulic structures for irrigation, water supply and sanitation.

2.3. Functional responsibilities of the main water agencies

The water governance structure demonstrates the complexity of the sector management and its regulation. Many government agencies are involved in the management of the water sector, which requires smooth coordination and action between these organizations for successful sector functioning. On establishment of the WC, management decisions are made collectively by their members. The WC practically regulates all major aspects of water resources management, including the approval of water projects for financing included into the approved action plan and for the current tasks arisen. The operating regimes of the water reservoirs are taken into strict control, timely corrections are made on inflow and outflows and the recommended operational regimes are approved. Regarding the efficient use of water resources of the liberated territories from occupation, a preliminary assessment of water resources has been carried out and relevant indicators have been included in the annual water balance, to make a more accurate assessment, installing water measuring devices on water bodies is being continued. Recently, on the rivers Tartarchay, Tutgunchay, Zabukhchay, Bargushadchay, Hekarichay, Kondalanchay, Guruchay, Okchuchay, Basitchay and Araz, 11 automatic hydrological station sets are installed for determining the water level, water intake, water temperature, water pollution and precipitation. A digital water map containing the water resources of Eastern Zangezur and the Karabakh economic regions is being prepared and it is planned to be integrated into the water map of the country and the EWMIS in general. Feasibility studies and project-estimate documents are being prepared for the construction of Zabukhchay, Hekarichay and Bargushadchay reservoirs.

The lately established ASWRA is currently at the stage of formation and structuring, the agency needs more support for the development of both the central management apparatus, as well as regional and local structures, both in terms of employees, equipment, and the availability of appropriate infrastructure.

According to the Agency's charter, it is the central executive body implementing a unified state policy and regulation, which includes:

-In the field of water resource management, the agency controls surface water and groundwater, in a sustainable and efficient manner. This involves assessing water availability, developing, and implementing water management plans, and regulating the use of water resources.

-In the field of water use, the agency participates in regulating the use of water resources, which includes issuing water-use permits, monitoring water use, and enforcing regulations related to water use.

-In the field of infrastructural development, the agency is responsible for developing and maintaining infrastructure for the use and protection of water resources, which includes operation and safety of dams, canals, and irrigation systems. The activities cover all project implementation periods, starting from feasibility studies and designing up to the construction, operation and maintenance.

-In the field of environmental protection, the agency participates to protect the environment from the negative impacts of water resource use and consumption, including water quality monitoring, soil salinity control, regulating the discharge of pollutants into water bodies, and enforcing environmental regulations related to water resources.

-In the field of water supply and sanitation, the agency is responsible for the water supply and sanitation facilities, wastewater quality and discharge into the water bodies, operation and maintenance of all related hydraulic infrastructure, development of the freshwater distribution and wastewater collection schemes. The agency also participates in developing and implementing policies and programs, monitoring the quality of water supply and sanitation services, and ensuring their safety.

- In the field of international cooperation, the agency collaborates with the related international organizations and agencies from other countries to exchange information and earn best practices, including participation in transboundary water management.

The MENR participates in the monitoring of water bodies, including flow measurements, water quality, elaboration of the programs for rehabilitation and development of the water resources.

According to the new functional responsibilities, in the regions, irrigation and water supply and sanitation services will be provided by the rayon WASOA. This is justified by the fact that the introduction of a unified management system for water supply, sanitation and irrigation services in the districts will ensure a more flexible and efficient infrastructure maintenance and operation, to provide good quality for each service by the economical use of available technical and financial resources.

In the upcoming years, turning of the ASWRA into the effective working body requires to be developed by the following integrated measures:

Assessment and Planning – conducting current water resource assessment, including challenges, opportunities, existing infrastructure, and legal frameworks, a strategic plan outlining short-term and long-term goals for the Agency;

Legal and Institutional Framework – finalizing organizational structure of the agency, including departments, roles, and responsibilities, ensuring the agency's accountability;

Capacity Building – investing in training programs for staff members to enhance their technical skills and knowledge in water management, hydrology, water quality monitoring, and other relevant areas. Foster partnerships with universities, research institutions, and international organizations to access expertise and advanced resources.

Data Management and Technology: implement modern data management systems for collecting, analyzing, and disseminating water-related data. Utilize remote sensing, geographic information systems (GIS), and other advanced technologies for monitoring water resources and predicting trends.

Stakeholder Engagement: Establish mechanisms for meaningful participation of stakeholders, including government agencies, local communities, NGOs, and private sector entities. Foster dialogue and collaboration to address competing interests and promote sustainable water management practices everywhere, including in the rural areas.

Integrated Water Resources Management (IWRM): Adopt an integrated approach to water resources management that considers social, economic, and environmental factors. Promote water conservation, efficiency measures, and ecosystem protection.

Risk Management and Resilience: Develop strategies for mitigating water-related risks, such as floods, droughts, and water pollution. Invest in infrastructure upgrades and disaster preparedness measures.

Public Awareness and Education: Launch public awareness campaigns to educate citizens about the importance of water conservation and sustainable water use practices. Integrate water-related education into school curricula.

Monitoring and Evaluation: Establish performance indicators to measure the effectiveness of the agency's initiatives. Conduct regular evaluations to identify areas for improvement and adjust strategies accordingly.

International Cooperation: Engage with neighboring countries and international organizations to address transboundary water issues, learning and sharing best practices.

Continuous Improvement: Foster a culture of continuous learning and improvement within the agency. To solicit feedback from stakeholders and incorporate lessons learned into future planning and decision-making processes.

Considering keeping in line the above policies and steps and continuously adapting to changing circumstances, the agency will be able to effectively fulfill its mandate and contribute to sustainable water management.

Beside the related water governance organizations, various research institutes and universities conduct studies on water resources, hydrology, water quality, and environmental impact assessment, providing expertise and knowledge to support water management efforts. These organizations work together to ensure sustainable management of water resources, protect water quality, and address challenges such as water scarcity, pollution, and climate change impacts. Collaboration and coordination among these entities are crucial for effective water governance and conservation efforts.

CHAPTER 3. CLIMATE CHANGE AND WATER MANAGEMENT

3.1. Analyse of climate change impacts on water resources

The on-going climate change has already influenced the water resources of the region and is expected to continue to render impacts in the country's economy. Due to climate change in recent years, the inflow of transboundary and boundary waters has decreased, and the flows of inland rivers have also reduced.

Azerbaijan is the end country located in the lower reaches of transboundary and border rivers, and is therefore highly dependent on the flows of transboundary and border rivers. On the other hand, demand for water in countries located in the upper reaches of the Kura and Araz Rivers continues to increase rapidly (Rzayev, 2017:1). According to measurements conducted by the meteorological services, statistics from the last 20 years show that although the frequency of low precipitation periods is increasing, short-term intense precipitation processes are increasingly occurring.

The snow measurement results evidently show reduction of the snow in the all-river basins of the country. Despite the moderate increase in 2024, except in Greater Caucasus north-east slope rivers basin, the snow cover is less than average perennial volumes (Table 7). There has been an increase in the variability of the average flow of the Kura River in recent years (Figure 3). In 2021, the water flow of the Kura River, compared to the long-term norm of 575 m^3/sec, was only 245 m^3/sec, which shows the high variability of climatic anomalies (NHC, 2022).

Table 7. Dynamics of snow cover in the river basins of the Republic of Azerbaijan

	Wateriness of snow cover, mm					
By the river basins	Average perennial	2020	2021	2022	2023	2024
Qanıkh rivers basin	82.7	66.5	76.5	69.3	46.3	55.3
Shirvan river basin	58.3	40.5	53.7	51.9	32.4	45.4
Greater Caucasus north-east slope rivers basin	64.1	54.1	51.5	56.8	18.5	11.6
Lesser Caucasus north-east slope rivers basin	58.7	45.9	56.0	47	30.6	47.2
Nakhichevan rivers basin	71.3	59.3	46.3	54.6	37.6	55.7

The dynamics of change in the Kura River flows make it difficult to plan water connected activities, including irrigation, water supply and power generation (NHC, 2023; NHC, 2024:2). The irregularity of the flow in the basin creates in some cases a threat of drought, and in some cases flooding along the riverbanks.

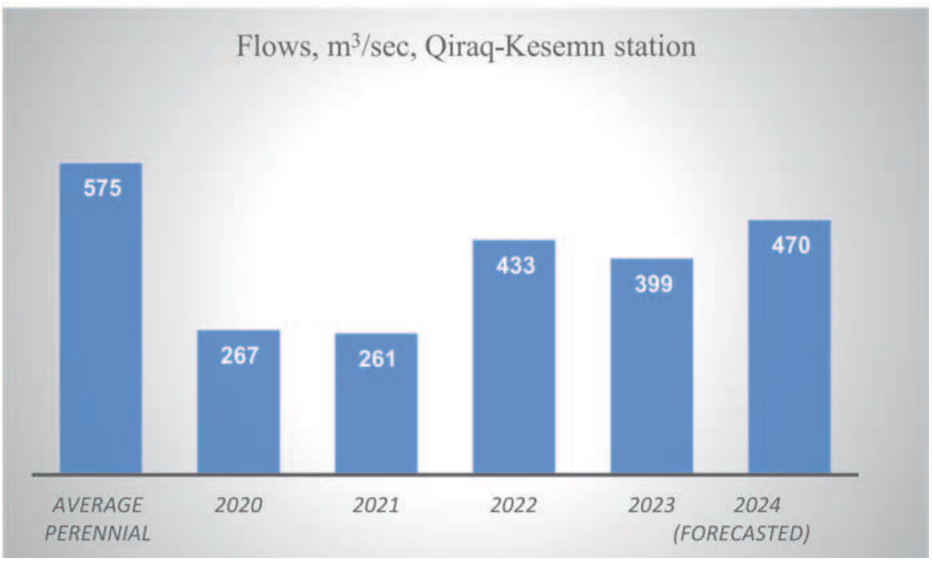


Figure 3. Kura River flows after entering to Azerbaijan Republic

Throughout the country, there is decline in precipitation, 14.3% decline in the Kura-Araz lowland, 17.7 % decline in the central part of the South Caucasus, Ganja-Gazakh and a 17.1% decline in Nakhchivan. On average, precipitation levels have declined by 9.9 % over the past decade. From 1991 to 2001, the mean temperature increased by 0.41°C. The average annual temperature increases from 1991 to 2001 is more than three times as high as the annual increase observed between 1961 and 1990 (0.36°C). The sensitive areas of special attention in terms of water security are the Absheron Peninsula and the Kura-Araz lowland. Given the high exposure climate change and the possible consequences, the Absheron Peninsula is considered a medium-risk zone in the short term, and in the long term it turns into a high-risk zone. The Kura-Araz lowland is an important agricultural region, an area heavily dependent on irrigation. The area is affected in ongoing salinization and desertification. The water supply and sanitation services in rural areas are limited. The increase in the ability to respond to natural disasters or risks caused by climate change in the lowland is important, as area is vulnerable to floods and droughts, approximately 15% of the population lives at risk of flooding. Risk management mechanisms such as early warning systems and agricultural insurance schemes need to be improved to help farmers or households respond to natural disasters. Thus, the Kura-Araz lowland belongs to zones with a high climate, an area of risk of change and security at the national level, both in the short and long-term (Ruchevcka et al., 2017).

According to the future climate modeling, it is expected, that in Azerbaijan in the coming decades, rising temperatures are likely to lead to more reductions in river flows, putting critical pressure on the fresh water. Based on the model estimations, by 2100 river flows is expected to fall by approximately 26–35%. Water shortages will be more severe in the arid regions of the country and could reduce crop yields. This negative effect can be softened if existing irrigation infrastructure problems, including water losses address properly (WB & ADB, 2021).

The enlargement of agriculture and the establishment of big size agricultural parks due to the development in the regions require a sustainable supply of water for irrigation and consequently rational use of the available resources.

There are difficulties in obtaining the planned crop yields due to the temperature rise and application of non-timely irrigation with the traditional methods. The rising crop productivity in the rain-fed farming zones requires irrigation as well. The occurrence of water shortage creates certain challenges not only in agriculture, but also in drinking water supply and hydropower generation. Therefore, in general, water use efficiency programs and projects are necessary to be implemented to satisfy sustainability of the supply in near future which is under the serious attention by the government and reflected in the adopted public programs such as State program of socio-economic development of the regions of the Republic of Azerbaijan in 2019-2023 and other publicly adopted documents (GoA, 2019:3).

3.2. Agriculture and irrigation

The agriculture sector is the main consumer which uses nearly 90% of water taken from various water sources. Water resources in Azerbaijan during the last 30 years, reduced by 15% and this negative tendency is going on in the country, accounting in 2023 totally 25,51x109 m^3 (CoM, 2023).

Most of the irrigated lands in Azerbaijan are located in the dry climate and with very low humidity in the summertime, therefore preferably agricultural farming is provided with the wide application of the irrigation systems. The irrigated lands exposed to the salinization and therefore the irrigation is applied with the combination of the drainage system for the soil salinity control. In addition, due to the wide application of the traditional irrigation methods the technological water losses approximately reaches up to 40% in the fields. Overall, during transportation water losses are on average 30% from the water taken from the natural sources. On-farm systems are mainly open type earthen canal systems, and irrigation is traditionally carried out mainly by surface irrigation methods (furrows, strips) in the fields (Table 8) (Ahmadzade & Hashimov, 2016).

Table 8. The main indicators of irrigation canals

1	Main canals	Open canals				Piped network	Total km
		Lined	Tray	Earthen	Total		
		1,058.2	10.0	1,040.7	2,108.9	30	2,138.9
2	Inter-farm canals	Open canals				Piped network	Total km
		Lined	Tray	Earthen	Total	267.3	
		1,187.2	80.4	7,132.3	8,399.9		8,667.2
3	On- farm canals	Open canals				Piped network	Total km
		Lined	Tray	Earthen	Total	5,921.0	
		3,020.7	1,518.4	31,525.1	36,064.2		41,985.3
Total length of all canals in the country, km							52,791.4

The share of canals with the earthen bed is 75% from the total operated canals. According to the investigations conducted on the irrigation infrastructure, water losses in on-farm systems differ depending on the canal type, its cross-section, the state of the hydraulic structures, the water-physical properties of the soil, location of the plots, the uniformity of the plot and the irrigation methods (Rzayev,2015). The 8,425 of the sub artesian and artesian wells are exploited to supply irrigation water to agricultural fields in areas where surface water is not available or limited. The irrigation upgrading projects being implemented under the currently realizing Action Plan (GoA, 2020:2), considers application of the new technological solutions to prevent unproductive water losses and better water management from the source in the fields.

Drainage water from reclaimed areas, for salinity control is discharged into the Caspian Sea. The land area covered by the drainage system is 610.7x10^3 ha, including 277.3x10^3 ha. are open, 320.4x10^3 ha. are piped, and 13x10^3 ha. vertical drainage networks. The 12,761 km open type, 9,269 km piped drainage networks, 6,683 km of main collectors and 4,302 km of main and inter-farm collectors (totally 33,015 km) are operated in the drained areas.

The cropping patterns in the country are formed considering the natural and economic conditions, the needs of the national economy and the market demand (Table 9).

Table 9. Sown area of agricultural plants

	2000	2005	2010	2015	2020	2022
Total sown areas	**1,041.5**	**1,327.9**	**1,583.9**	**1,585.4**	**1630.9**	**1624.0**
Cereals and dried pulses	**648.2**	**802.3**	**968.0**	**952.1**	**989.1**	**985.7**
including:						
wheat	495.4	591.5	657.7	539.7	588.4	547.2
maize	31.9	31.7	29.9	36.9	33.7	30.5
barley	108.5	167.1	264.7	361.0	345.0	386.3
rice	4.5	2.3	1.6	1.2	3.0	3.1
leguminuous	7.3	9.4	12.2	11.0	12.7	11.8
other	0.6	0.3	1.9	2.3	6.2	6.8
Industrial crops	**118.2**	**132.0**	**52.6**	**38.7**	**122.0**	**125.2**
including:						
cotton	101.2	112.4	30.2	18.7	100.3	104.3
tobacco	8.1	2.8	1.4	1.4	3.1	2.4
sugar-beet (for manufacture)	2.5	3.0	8.5	4.9	5.0	5.0
sunflower for seed	4.3	11.1	9.0	10.7	11.0	11.5
other	2.1	27	3.5	3.0	2.6	2.0
Potatoes, market-garden crops and vegetables	**136.1**	**179.7**	**178.8**	**166.0**	**143.6**	**140.3**
including:	.					
potatoes	52.5	70.7	65.8	61.0	57.0	54.8
vegetables	56.8	78.9	81.1	77.2	66.6	65.4
market-garden crops	26.8	30.1	31.9	27.8	20.0	20.1
Forage crops	**139.0**	**213.9**	**384.5**	**428.6**	**376.2**	**372.8**
including:						
perennial plants	122.6	202.7	377.3	416.9	360.1	364.5
annual plants	13.9	10.1	5.8	9.8	13.5	6.7
maize for silage and other	2.5	1.1	1.4	1.9	2.6	1.6

Totally, in 2023, the country's gross domestic product was 123 billion AZN (or 72.35 billion US Dollars), from which the share of agriculture sector was 5.5%. The diversity of natural conditions makes it possible to grow different plants, including for export to other countries. The main exported goods are fresh fruit (378,554 tons), vegetables (169,008 tons), potatoes (78,301 tons), tea (1780 tons), cotton fiber (75,070 tons) and others (SSC, 2023: 1). In upcoming years the exports are expected to be increased due to the development of the agricultural parks' big size farms, for intensive farming and crop processing. Currently, 51 of the agricultural parks occupy 239,300 ha, total of 1.5 billon USD already invested.

To improve water accounting system, in recent years', digitalization in agriculture made it possible to provide more efficient distribution and use of the irrigation water among the water users. Development of EAIS allows integrating, processing and obtaining information on the all water related data (GoA, 2019: 1).

Information about the water abstraction and use in agriculture, as well as abstraction and supply of water for irrigation systems is yearly collected by ASWRA and submitted to SSC. For the on-farm irrigation water supply, farmers and agricultural producers apply to the SADC, WASOA of ASWRA or WUUs to plan irrigation schedules. Data on the water abstracted for irrigation shall be collected by the water users and transferred in paper format to the local body of ASWRA. The completion of the data shall end by January 25, 2025. ASWRA collects all information from all sources and submits a summary report to SSC by April 25 or transforms in electronic form to website of the SSC. At the beginning of each year, all water users declare about their sown structure, irrigated lands, thus defines the volume of required water for irrigation via EAIS. By the end of the current year, the data about the applied irrigation in the fields gives a clear picture of the agricultural water use.

ASWRA keeps records and prepare the annual *Cadastral Report of Land Reclamation and Water Management Facilities* on irrigated and irrigable lands by evaluation of the irrigation facilities and ameliorative condition of the soil.

The volume of the abstracted water from the pumping stations and sub-artesian wells can be alternatively monitored by the consumed power. In the case of gravity systems, water meters, and water measuring gates provide information on the volume of the water consumed.

For the big size dams, water abstraction and distribution are controlled by ASWRA, MENR, Azerenergy JSC, which are responsible and participate in preparation of the water balance for each year.

MoA controls the information supplied by the farmers on the sown area, who plan to get subsidies. In most cases, monitoring is organized at the level of the plots via field investigations or with the application of the satellite services of "Azercosmos" OJSC to check local data.

Currently, the information input by the farmers on the irrigated lands and crop patterns controlled by MoA, this control is executed by the composing of the irrigation schedule through EAIS, which gives confirming information about the irrigated lands and volume of the water supplied the fields based on the crop pattern.

3.3. Water supply and sanitation infrastructure

Until the 18th century, Baku city was supplied with water from wells. In 1917, the Shollar-Baku pipeline was put into operation, which until now provides Baku city and surrounding areas with high-quality drinking water (Imanov, 2016). During the former Soviet time, rapid development of water supply and sanitation infrastructure in the country had taken place particularly in urban and industrialized areas, the focus was primarily on developing industrial and urban centers. The rural communities often faced challenges in accessing clean water and adequate sanitation services. Additionally, environmental concerns related to industrial pollution and inadequate wastewater treatment emerged as significant issues during this time. After gaining independence in 1991, the country has been putting huge investment into the water supply and sanitation sector. Currently, the number of households covered by services also prevails in urban areas (Table 10). (SSC, 2023:2).

Table 10. The rate of the household's coverage with water services

The name of service	Country	Cities	Rural places
Centralized water supply	66.6	93.8	32.8
Private water supply	37.4	10.9	70.6
Centralized hot water supply	6.5	8.1	4.6
private hot water supply	94.3	93.0	95.9
A sewer line connected to a centralized sewer system	55.9	86.7	17.5
Sewer line connected to private sewers	47.2	18.8	82.5
Sanitary WS	96.2	98.1	93.8
Bath or shower	97.1	98.8	94.9

Currently, along the country, a total of 46 water sources are under exploration. The 2,824 km of water pipelines, 19,727 km of water supply networks, 598 water pumping stations are operated. The 11 water treatment units with a total capacity of 25 m^3/sec are operated for drinking water supply. In the country, 29 wastewater treatment plants with 0,8x106 m^3/day capacity are under the operation. The length of sewer collectors is 779 km, the network length is 10,221 km, the number of wastewater treatment facilities is 35, and there are also 178 units of sewage pumping stations. During the last two decades, reconstruction of drinking and wastewater infrastructures was carried out in 54 cities and regional centers, network construction works were completed in 32 cities. Due to the developing infrastructure, the number of consumers supplied with drinking water increased from 2.7 to 8 million compared to 2003, including the proportion of the population provided with uninterrupted drinking water from 26% to 78% across the country, and this rate in Baku city has increased from 29% to 80% (Mikayilov, 2024).

To ensure the safety of water supply, the Baku region is provided with fresh water from five independent sources: Shollar pipeline, Second Baku pipeline, Jeyranbatan, Kura water treatment plant complex, Oguz- Gabala-Baku's main water pipeline (Nagiyev, 2021). Shollar and Second Baku pipelines are underground water sources of Khachmaz region and Oguz-Gabala-Baku main water pipeline, transport water from the Oguz region. The Jeyranbatan reservoir is the surface water resources which is fed by the Samur River, and the Kura pipeline is fed from Kura River. The Oguz-Gabala-Baku pipeline is the latest constructed water source for the city of Baku, with a capacity of 5m^3 /sec, a length of

262.5 km, operating in gravity mode using DN2000 mm fiberglass pipes. The source of water is groundwater collected by 78 drilled wells; in addition there are 20 monitoring wells. The underground water for 200-250 x10^6 m^3 water supply is abstracted by the sub-artesian and artesian wells.

3.4. Industrial and other users

The municipal water consumption is estimated at 329x10^6 m^3. Water for industry use accounts for around 2.5x109 m3 per year. The increase of the industrial water consumption from 2010 up to 2023 is about 41%. During this period the consumption of drinking water by the industry users increased from 54 to 90x$10^6$$m^3$.

Reduced river flows have impact on hydroelectric power generation, which depends on water flow and water pressure. Thus, compared to 2005, hydroelectric power generation dropped down from 3x109 kWh to 1.596 109 kWh. in 2022, which accounts for 5.5% from the totally generated energy in the country. Therefore, in order for the efficient use of the available energy potential of the water flows, the installation of hydropower generation facilities is considered in the construction of the new reservoirs and reconstruction of the irrigation canals, which are under realization by the adopted Action Plan and other government programs (GoA, 2020:2; GoA,2022:3).

3.5. Trends on depletion of water resources and recent policy arrangements

In Azerbaijan, the issue of efficient use of water resources and their accessibility to everyone is considered in all recently adopted water related government documents and programs, including in regional development programs and participating in international initiatives. Azerbaijan actively participates in international initiatives related to water resource management and climate change adaptation. This involvement includes collaboration with international organizations and neighboring countries to manage transboundary water resources effectively (Strosser et al, 2017). Investments in water infrastructure, such as dams, reservoirs, and irrigation systems, are part of the government's efforts to improve water availability and efficiency. Efforts to educate the public and raise awareness about water conservation and sustainable practices are integrated into government initiatives. These include; consulting companies such as "Let's protect a drop of water", Caspian Water Innovation Forums, Baku Water Week and other initiatives effectively (RIA, 2023; CWIF, 2023; ASWRA, 2024).

Future impacts of climate change are expected to continue to impact negatively on water resources. Forecast calculations show that surface water will decline by 23% from 2021 to 2050. Given that climate change may also negatively impact groundwater resources, the role of stormwater and desalinated water becomes more important due to dry and hot weather conditions. Rising temperatures will further place pressure on agriculture, making it more vulnerable to pests, diseases and changes in biodiversity.

Higher temperatures will also increase potential evaporation and prolong dry seasons, thereby increasing the amount of water needed to meet demands for drinking water, crop irrigation, and reducing water withdrawals due to environmental flow demands (Abbasov et al., 2022:2).

Thus, the scarcity of fresh water resources, the global climate change and the increase in observed on-going average temperature in recent years, the reduction of surface water resources, precipitations, flows in rivers, dependence from the transboundary water, on the other hand, the rapid population growth, the rise of living standards, the country's economy, including the increase in water demand as a result of the development of agriculture, the expansion of farmlands, irrigation and drinking water supply networks requires implementation of rapid integrated measures to ensure the water security in the country.

Under the new conditions, the country's water policy and infrastructure need further improvement to solve problems by developing a new view of the water sector, including in the context of improving it as a save ecosystem service through the widespread use of innovations, investments, database development and advanced institutional mechanisms. Taking into account the situation, in order to increase water resources and improve the supply of drinking and irrigation water to consumers, in 2020 "Action Plan for 2020-2022 on ensuring efficient use of water resources" has been adopted (GoA, 2020:2).

The Action Plan contains a set of measures in the following areas:

- Assessment, protection and sustainable use of water resources;
- Digitalization of water management, improvement of accounting and data delivery;
- Increasing efficiency of the water use resources in energy generation;
- Efficient and economical irrigation water use, development of the new water resources;
- Improvement of drinking water supply system;
- Increasing efficiency in the field of financing infrastructure projects;
- Information spread and awareness raising.
- Improvement of land reclamation, degradation and desertification control.

The Action Plan includes construction of ten reservoirs as well as rehabilitation of hydraulic structures, irrigation canals and collectors. The reservoirs are planned to collect mountain river water to be used for irrigation and water supply schemes.

The WC tasked to coordinate state bodies (institutions) to mobilize Action Plan implementation and provide regular information to the President of the Republic of Azerbaijan about the results of the work done. The WC also ensure cooperation with scientific institutions, specialist, non-governmental organizations, international experts and international financial institutions for the efficient and economical use of water resources for irrigation, drinking water supply, energy and industry and participate in coordination of the measures related to the construction, reconstruction, restoration of water facilities, supply of drinking water and irrigation water, as well as rainwater management in the territories released from long term occupation.

Since the establishment of the WC, continued inter-ministerial work has been established in various formats on irrigation, municipal water supply issues and the ways for their solution. Thus, water resources allocation and management has been gradually improving and implementing to meet water users demand within environmental requirements. The commission acts currently as the key regulator of the sector, which supports acceleration of the transition to the principles of integrated water resources management to the benefit of all users.

As a result of the actions taken, Azerbaijan has made progress on the SDGs, including in the line of SDG6 target for clean water and sanitation. Azerbaijan was ranked 54th among 166 countries in the UN Sustainable Development Report for 2020, achieving 72.6 points out of 100 for the "Sustainable Development Goals Index", against 70.9 points in Eastern Europe and Central Asia. Change in water-use efficiency over time is reached from 3.73 (2020) to 6.57 USD/m^3. The proportion of wastewater safely treated reached 56.2% in 2022 in comparison with the 47% in 2017. Regarding the water stress level indicator, i.e. freshwater withdrawal as a proportion of available freshwater resources reached 57.5% in 2022 (UN, 2021& UN, 2022).

In 2021-2022, the "European Union for Environment" (EU4Environment) Action, within the project; "Designing Green Public Investment Programme and Conducting Training in Azerbaijan" supported the country in improving water demand management and the efficient use of water resources, by proposing pipelines of smaller-scale priority investment projects. The project also supported to facilitate knowledge transfer and encourage experience sharing between the EU and its Eastern Partnership (EaP) countries on best practices and lessons learnt in preparation and implementation of large-scale (national) public support programs and approaches to water supply and wastewater treatment in rural and remote areas (OECD, 2023).

CHAPTER 4. WATER TARIFFS AND INVESTMENTS

4.1. Current water tariff regulation and policies

The legal basis of paid use of water in Azerbaijan is regulated by the following legislation:

-Water Code of the Republic of Azerbaijan;

-Law of the Republic of Azerbaijan "On Amelioration and Irrigation";

-Law of the Republic of Azerbaijan "On water supply and waste water";

-Rules of "Issue and connection of technical conditions for the connection of consumers to the water supply and wastewater discharge system" approved by the Decision of the Cabinet of Ministers No. 275 dated 13.08.2014;

-"Water Use" Regulations approved by Cabinet of Ministers Resolution No. 262 dated 17.07.2014;

-Rules of "Paid use of water in the Republic of Azerbaijan" approved by Resolution No. 95 dated 17.03.2022 of the Cabinet of Ministers.

Currently, applied water tariffs for the different consumers varies, depending on the purpose of the water use (Table 11)

Table 11. Water Tariffs in the Republic of Azerbaijan for different consumers

	Type of services (by the consumer group)	Tariffs*, AZN/m^3 including VAT
1	**Water Supply**	
	Residential, including for Baku, Sumgait, Ganja, Mingechevir, Shirvan, Khirdalan and Absheron regions	0.70
	Residential for the other administrative regions	0.60
	Budget and other equivalent organizations	1
	Other consumers (production, trade, service, commerce)	1
	Consumers using water as a raw material	8
2	**Waste water discharge**	
	Residential consumers	0.30
	Other consumers (not depending on the type and ownership)	1.0
3	**Agricultural water supply**	
	Irrigation	0.5 AZN/1000 m^3
	Water supplied to winter pastures and meadows	0.4 AZN/ ha

The monthly water consumption rate for the non-metered residential consumer group is appointed 5 m^3/month. The payment for the wastewater discharge service is only carried out if the relevant service network is available in the area.

The latest tariff for irrigation and winter pastures and meadows was adopted in 2006 and remains in force from that date (TC, 2006). Tariffs for water supply and wastewater discharge services which adopted in 2016, was amended in 2021 by the new decision of the TC (TC, 2021).

The rules of “Paid water use in the Republic of Azerbaijan” define the basic principles of paid water use by water management institutions and organizations under the new conditions (GoA, 2022). The main purposes of the adoption of the Rules is to ensure coverage of public expenses spent on water supply, ensure the establishment of principles of self-financing of water management organizations, formation of their financial interest in the efficient and economical use of water resources and improve water protection, conduct accurate water accounting and stimulate investments into the water resources management.

The water fee must be differentiated by the separate water management systems, depending on water quality, purpose of use, technical condition of water management facilities, water intake and transportation methods and other factors influencing the volume of production costs. The water fee taken from the water, from water bodies for special purposes, shall be paid to the state fund for environmental protection.

The Rules stipulate that no fee is charged for water taken from natural water sources (water bodies) for the raw (untreated) water for irrigation and water supply and water taken for electricity generation. MENR carries out water resources (surface and underground water) accounting by the water bodies, in compliance with water use schedules and payments.

Based on the adopted rules, the new water usage fee (tariffs) is currently under consideration by the government.

4.2. Investments into the water sector

During the last two decades, Azerbaijan has invested more than 3 billion USD on development of the water economy infrastructure, including irrigation canals, dams, water supply and wastewater facilities (Winston et al, 2022). Every year, the government allocates targeted funds from the public budget for maintenance, operation of the existing infrastructure, rehabilitation and implementation of the new projects.

The total budget allocation in 2022 for amelioration and irrigation measures was 691.1 million AZN, from which for maintenance and operation costs was 418.6 million AZN, and construction works 272.5 million AZN. The budget for maintenance and construction in 2023 was 465.8 million AZN. In 2024, similar measures is planned for 499.8 million AZN, which is 7.3% or 34 million AZN more than in 2023 (AAWM JSC, 2022; GoA,2022:2; GoA,2023:3).

In 2022, investments financed from the state budget for water supply and sewerage systems amounted to 591 million AZN, against 237.8 million AZN in 2021. Investments financed by international financial organizations with state guarantees amounted to 156.1 million AZN. Considering the investments made in the form of non-financial assets, the total volume of public investments in 2022 amounted to 1.16 billion AZN and in 2021 – 806 million AZN (Azersu JSC, 2022). The increase in investment is associated with intensive construction and restoration works not only in climate change affected regions, but also in the territories liberated from Armenian occupation after 2020. The budget allocation for water supply and sanitation projects in the released territories is allocated depending on plans for resettlement of workers and population.

The government has established close cooperation with international financial institutions, which are also involved in the implementation of projects in the water sector (Table 12).

Table 12. The projects implemented within international financial cooperation

	Name of the Project and start date	Source of funding
1	Water Supply and Sanitation Investment Program, 2008	Asian Development Bank
2	National WS and Sewerage Services Project I, 2007	World Bank
3	National WS and Sanitation Project in 6 regions of Azerbaijan, 2012	Islamic Development Bank
4	The Project of "Open Municipal Infrastructure Program II", 2006	KfW Bank of Germany
5	Water Supply and Sewerage Project in Towns,2009	Japan International Cooperation Agency

Continuation of Table 12

6	Reconstruction and expansion of water supply and sewage systems in Khirdalan city,2017	Saudi Fund for Development
7	Development of water supply and sewerage system in Kurdakhani settlement,2012	Koreya International Cooperation Agency
8	Reconstruction and expansion of water supply and sewerage systems in Badamdar settlement,2015	Local and Saudi Fund for Development

To upgrade on-farm irrigation systems and strengthen the IMT (irrigation management transfer) process, in cooperation with the World Bank group, since late 1990s, the government had implemented four infrastructure upgrading and institutional capacity building projects (Table 13).

Table 13. WB supported irrigation rehabilitation and WUU support projects

	Name of the Project	Funds, mln. US$	Date
1	Farm Privatization Project (FPP)	28.80	1997-2003
2	Rehabilitation & Completion of Irrigation &Drainage Infrastructure	46.86	2000-2007
3	Irrigation Distribution System & Manag. Improvement	43.80	2003-2010
4	Water Users Association Development Support	114.3	2011-2018

ADB supported "Irrigation and Drainage System Development in Nakhichevan Autonomous Republic" which intends to use high-level technology for the rehabilitation and modernization of five irrigation systems covering more than 23,230 ha. of irrigated farmland, accounting for about 80 percent of the total irrigated land in in Nakhichevan (ADB, 2020).

The statement of the President of Azerbaijan, Ilham Aliyev about the current main goal of the state, to achieve 100% supply of drinking water for all population of the entire country (President Administration, 2023) is being served to SDG goal by realization of the new projects in water supply and sanitation with the application of the advanced technologies. In the last two decades, 8 large water reservoirs (including Takhtakorpu, Shamkirchay, Tovuzchay, Goytepe) with a total water capacity of 500 million cubic meters have been built or repaired in the country by capital investments (Asadov,2023).

Within the framework of the implementation of the Action Plan (GoA, 2020:2), for increasing water resources, preparation of feasibility studies and project documents, for the development of 12 reservoirs on the inland rivers are under preparation, which aims to reduce the country dependence on the transboundary flows by the efficient mobilization and use of the internal water resources. Feasibility studies and project documents were prepared for the reconstruction of 22 hydro junctions.

It is intended by the Action Plan, to improve the supply of drinking water to the population: increasing the productivity of the Oguz-Gabala-Baku aqueduct and the Second Baku aqueduct, development of the 3rd Shollar water source (5 m^3/sec), altering the water sources where the effects of climate change have been observed.

The goals for development of water sector in Azerbaijan, expanding water services and improving their quality, determine the needs for the future investments and to prepare projects feasibility studies. The implementation of water projects under the current challenges of climate change requires strictly regulating environmental requirements and consideration of all safety aspects in the projects. During the projects preparation periods, organizing public hearings and coordination with the local communities for awareness and interested stakeholders needs satisfaction, to achieve consensus and smooth implementation are carried out.

4.3. Water projects in the territories liberated from occupation

The great return to the territories freed from occupation has been identified as one of the five main national priorities of Azerbaijan till 2030. In 2022, for this purpose, the "I State Program on the Great Return to the liberated territories of the Republic of Azerbaijan" was approved (GoA, 2022:3). The document defines targeted measures for the restoration of irrigation, water supply and sewerage systems for all areas and cities liberated from occupation. In projects related to the development of water infrastructure, among other issues such as restoration of forests, flora and fauna, the use of environmentally friendly technologies, issues related to the efficient use of water resources are identified as one of the main priorities.

During the Armenian occupation, the water management and reclamation infrastructure was seriously damaged. In addition to the complete destruction of the residential settlements including 9 cities, the 9 water reservoirs, 2 hydro-junctions, 7 water storages, 6,426 km of irrigation network, 330 km of collector-drainage network, 8,003 hydraulic structures, 88 pumping stations and 1,429 sub-artesian wells and as well as, 125,800 ha of cultivated land has become completely unusable due to looting and absence of maintenance during the occupation period (Pashayev, 2021).

Currently, rehabilitation and restoration of the water facilities in the released territories has been under implementation. The restoration of Sugovushan hydro-junction in 2023 allows Tartarchay Right and Left canals enable to transport 50m^3 /sec and 20m3/sec water flows respectively. In total, it improves irrigation water supply of 96,217 ha lands located in downstream rayons.

In the liberated territories, the restoration of five reservoirs and the Tartarchay Left Bank Canal has been completed. Restoration and reconstruction work has been completed on the Sugovushan reservoir with a volume of 5.86x10^6 m^3 and a main canal length of 5.2 kilometers, as well as on the Khachinchay reservoir with a volume of 23x10^6 m^3 and a main canal 7 km, and all structures were put into operation in 2023.

On the Kondalanchay River, 3 reservoirs with a total volume of 15.5x10^6 m^3 have been reconstructed and put into operation in 2024. On the Tartarchay Left Bank canal, 20.2 km long, with a flow rate of 20 m3/sec, a 20.17 km section is covered with concrete, a mudflow diversion canal 2,066 m has been built, and SCADA systems installed on the canal.

The feasibility study and design documentation for the restoration of reclamation and water infrastructure in the liberated territories of the Agdam, Fuzuli and Jebrail regions are being intensively implementing. These projects include the completion of a feasibility study and design documentation for a main canal, 56 km long from Qiz-qalasi dam, as well as the Hekerichay dam with a volume of $90.8x10^6$ m^3, in Lachin rayon, and the Bergushadchay dam with a volume of 67 x 10^6 m^3 in the Gubadli region. To provide irrigation water to agricultural fields located on the right and left banks of the Hekerichay river, the Zabukhchay reservoir with a capacity of $26.7x10^6$ m^3 and a main pipeline 51.6 km long were designed, and actual construction work have started in all mentioned facilities. The construction of the Zabukhchay dam will provide 12,000 ha. agricultural lands with irrigation water (Mikayilov, 2024). Sarsang Reservoir, which was built and put into operation in 1976, on the Tartarchay River with a total operational volume of $500x10^6$ m^3 during the occupation period, became poor condition due to the neglect of technical facilities. Currently, the reservoir rehabilitation plan is under preparation.

4.4. Public-private partnership initiatives in water sector

In recent years significant efforts have been made to develop public- private initiatives through planned projects with the private sector participation in water sector. The issue of the efficient use of water resources requires proper management and commercialization of water services to ensure sustainability of the sector development. In this view, one of the main goals is to reduce the state's funding burden, ensure the interests of all parties in accessing and use of the quality water services. Therefore, the policies shall ensure the attraction of the private investment in the water sector through appropriate state regulatory mechanisms for the smooth and sustainable development of the water industry.

The adopted Law of the Republic of Azerbaijan "On Public-Private Partnership", regulates relations in the field of public-private partnership, including public-private partnership projects, development and management of technologically advanced water infrastructure in the country (GoA, 2022: 4). The Public-Private Partnership Rules were adopted in accordance with the above Law by the Decision No. 167 of the Cabinet of Ministers dated 18.03.2024 (GoA,2024,2).

The government has initiated implementation of the pilot project in the field of drinking water production through desalination of sea water, which demonstrates the government efforts to overcome water scarcity through using of the sea water resources and mitigate water shortage (GoA, 2023:4). The purpose of the project realization is to improve the water supply of Baku city and surrounding areas to increase the water security of the country, supply of high-quality drinking water to the consumers and attract new technologies to the water treatment business.

A team of the qualified experts have been selected for the implementation of the project and a set of requirements and conditions has been prepared for the interested companies, willing to participate in the project. At present, tender procedures for the collection of proposals have been organized. According to the planning, the capacity of the water desalination plant is set at 100 x 10^6 m^3/year. The costs related to the construction of the plant will be covered by the private partner, and the government will provide set of privileges for the private partner for plant installation, operation, and maintenance for the total period of 25 years.

The government decision on measures for the implementation of the pilot project related to the treatment and reuse of wastewater discharged from the Hovsan aeration plant into the Caspian Sea was adopted to increase the use of alternative water sources, treatment and reuse wastewater, as well as attract new technologies to the wastewater treatment process (GoA, 2023: 5). This plant treats sewage water collected in the Baku city area and discharges them into the sea. The WC has been assigned to coordinate the activities for the implementation of the above pilot project and currently preparatory activities for implementation of the project are organized.

CHAPTER 5. FUTURE WATER RESOURCE MANAGEMENT

5.1. Water resource forecasting and demand for the future

The population of Azerbaijan has reached 10.2 million in 2024, and due to future population growth in the country, about 11 million inhabitants are expected to be reached by 2040. Certainly, the increase in population and future economic development will require more water for the different consumers, including agriculture, municipal water supply and sanitation, industry and hydropower and others.

The area of irrigated land in 2022 was 1,484,900 ha. Compared to 2010, the sown area of cotton increased by 30,175 ha. and reached 104,267 ha. in 2022 (SSC, 2023:3), which led to rise of the consumption of irrigation water, especially in the Kura-Araks lowland. Therefore, while selecting crop patterns in irrigated lands, the availability of water should be considered.

Azerbaijan's water resources are expected to be decreased up to 40% by 2100. The water requirement of the irrigated land can be satisfied by proper water resources management in agriculture. If current water losses are reduced and the transition to modern irrigation systems is ensured, then the surface water resources, expected to be formed by 2040 will be able to provide irrigation water of the currently irrigated lands. The reduction of existing water losses, the construction of concrete-lined canals, construction of the new reservoirs, consolidation policy for the arable lands, expansion of the network of piped and modern irrigation systems, the optimization of crop pattern based on the availability of water resources, reuse of treated wastewater are the key arrangements for solving the water shortage problem.

Currently, the drinking water of 67% of residential consumers is provided by a centralized water supply system, which is met through surface and underground water sources. In the areas where a drinking water supply network is available, 88% of consumers are equipped with the meters for the proper water accounting.

According to the requirements of regulatory documents, 28.4 m^3/sec (or 894x10^6 m^3/year) throughout the country it is necessary to ensure the uninterrupted supply of drinking water to all population.

According to the forecast, it is expected that reduction in current water supply will fall from 37% to 20% by 2024. Water requirements for the Absheron Peninsula, including Baku city is expected to be 18.5 m^3/sec, regions 22 m^3/sec and Nakhichevan AR 1.5 m^3 /sec. The expected water requirement, certainly needs to put into operation the new sources of drinking water in the regions and implement water loss reduction programs in the operated networks.

To ensure the quality and full of drinking water supply to the population, it is necessary to take measures to improve the water infrastructure, including upgrading existing water supply systems, development of the precise accounting, new water sources, using alternative water sources, introducing smart water technologies and reducing existing unproductive network and commercial losses.

In the future, to meet the water demand of industry and other users, through water recycling and its reuse after treatment, should also be considered a priority. Currently the total annual reserve of wastewater in the country is estimated at 5.1 x 10^9 m^3, which demonstrates the high potential of this source to be utilized by the different industries to overcome water shortage.

The government has recently taken serious measures for efficient use of water resources. The country's largest main irrigation Karabakh canal, supplying up to 115,000 ha. of agricultural land with irrigation water, supports the domestic water supply of the population in the Karabakh zone and 9 districts located in nearby areas. In the context of the growing challenges from the recent global climate changes, in order to prevent water losses, more sustainable use and supply of irrigation water, improve the lands ameliorative condition and the ecological state of the surrounding territories, the government decided on a complete reconstruction of the Karabakh irrigation canal, and the relevant authorities were entrusted with the preparation of a feasibility study and design documentation (GoA, 2024:3).

Also, the second largest, the Shirvan Irrigation Canal provides irrigation water to more than 112,000 ha. of agricultural land and residential areas with household water in 8 districts located on the Shirvan Plain. Despite the ongoing and major repair work on the canal during its continuous operation for more than 65 years, due to the deformation of the ground bed and the severe loss of operational functions of the canal structures, there has been an increase in water losses. In this regard, feasibility study and design documentation for the reconstruction of the canal have been prepared. Considering the operational condition of the canal, the government has decided to completely rehabilitate the canal and therefore ASWRA and other relevant organizations have been tasked to take appropriate measures for the canal reconstruction (GoA, 2024: 4). Thus, the reconstruction of the Karabakh and Shirvan main water canals, fed from the Mingachevir reservoir, will eliminate water losses; improve water accountability and water distribution across service areas.

The above measures, along with increasing the installation of modern irrigation systems at the on-farm level, as well as optimizing the crop pattern in agriculture, improving the culture of water use by farmers at field level, careful use of water by the population and other consumers will help to significantly mitigate the problem of water shortages in the country.

5.2. Transboundary river water use and cooperation

In the context of climate change, there has been a significant decrease in precipitation and river water flows because of an increase in the duration of the dry season in the hot months of the year, thus, there is a tendency in the reduction of water resources in transboundary and border rivers. Over the past 70 years, there has been a clear trend towards a decrease in the Kura River. In Azerbaijan, from the Mingachevir reservoir to the confluence of the Araz River, this decrease in Kura River flows is estimated around 32-44%. The annual flow of the Araz River decreased over the entire observation period up to 44%. It has been established that for the period of 1950-2010, annual river flow Ganykh flow decreased by 11.1 m^3/s or 9.17%. Over the period 1969–2006, the Samur River experienced a decrease in annual flow compared to the period 1950–1968 by 16.5 m^3/s or 21.8%. The same situation is observed in the other transboundary rivers (Imanov, 2016)

The South Caucasus region is located around transboundary river basins. Geographically, water resources are unevenly distributed among the states of the South Caucasus region. The dependence of the Republic of Azerbaijan on transboundary waters is 70% of the total water use. Water consumption increase during the last three decades in Azerbaijan has been observed by 7%, East Georgia 7.0%, Armenia 8.5% and Iran (4.1%) (Rzayev, 2017:2). Thus, in the Kura-Araz river basin, use of the water resources by the each of the five countries Azerbaijan, Türkiye, Iran, Georgia and Armenia is intensive due to the construction of the new reservoirs for agriculture, hydropower development, and drinking water supply. Azerbaijan, due to agriculture development recently, enlarged irrigated lands which increase in water consumption by 1.22 km^3. Georgia and Armenia also implemented planned increase of the area of the irrigated lands to 225,000 and 454,000 ha, with the required water withdrawal of 1.08 and 2.13 km^3. The increase in water consumption in other countries of the basin will cause an inevitable steady decline in river runoff entering Azerbaijan territory. The inflow into the Caspian Sea, also considerably decreased because of the higher internal water withdrawal in the countries in the basin. With the anticipated extension of agricultural lands and the current poor management and wasteful water use, the required total water withdrawal from the Kura River can reach 17.7 km^3, resulting in a complete cessation of water discharge into the Caspian Sea (UNDP, 2013). This prognosis had already been taken place in Azerbaijan, as of 2020, due to a sharp decrease of the Kura River flows towards the river mouth, the Caspian Sea water flowed back into the riverbed, which seriously damaged the irrigation and drinking supply of the Neftchala and Salyan districts. Under this situation the government had to take urgent actions to prevent sea water flowback into the river bed and secure water supply of settlements through comprehensive hydraulic measures, as well as installation of the new water supply system (Rzayev, 2023). Decrease in the runoff at the territory of Azerbaijan and by extension, the Kura basin has impacts and creates risks in terms of environment condition of the river ecosystems, including degradation of specific ecosystems and natural landscapes, weakening of river's natural ability to recover itself, increase in the concentration of pollutants and loss of agricultural land fertility due to the lack of irrigation water, more intensive use of groundwater (EUWI, 2021).

In the other hand flowing out untreated water and pollution of the Kura River basin, where ¾ part of Azerbaijan is located, worsening water quality before entering the country from upstream countries. In Georgia, for many years into River Kura, flowed waste industrial waters, that contained about 70 different substances, toxicants among them. The discharges from metallurgical and chemical plants into the river contained about 10 mg/l of suspended substances, including 30 mg/l of ammonia, 2 mg/l of phenols, 0.3 mg/l of pyridines, and 0.1 mg/l of cyanides. Such composition of waters, 100 times exceeds the limited permissible concentrations (Lomsadze et al, 2016; Gurgenidze & Romanovski, 2023; Mchedluri et al, 2024). According to the periodically organized river water monitoring by the MENR of Azerbaijan, the concentration of the copper, molybdenum, zinc, phenol and petroleum content has higher concentration exceeding maximum allowable concentrations. In the Okhchuchay River, which formed entirely in the territory of Armenia, samples taken at the entrance to Azerbaijan indicates that because of wastewater drainage of mining areas, heavy metal concentrations in the river significantly increased and the river lost ability to provide ecosystem services (Abbasov et al, 2022:2). Thus, the Okhchuchay (in Armenian named Voghji) River is polluted with high levels of molybdenum, manganese, copper, zinc, iron and vanadium. Due to prolonged pollution of the river's lower runoff, the concentrations of molybdenum (50 times) and manganese (1.2 times) exceeded the FAO maximal allowable concentration irrigation water. An assessment of water quality based on irrigation hydro-chemical indicators showed that the lower water flows of the river are unacceptable and toxic for irrigation (Margaryan, 2017; Gabrielyan et al, 2018). Drainage water and wastewater from mining regions caused a dramatic increase in heavy metal levels in the Okchuchay River basin in Armenia. As a result, the river water was sharply worsening with the elevated concentrations of heavy metals (Anh etal.,2023).

Pollution in the Kura and Araz rivers downstream the Mingachevir reservoir mainly originated from untreated sewage, organic-chlorine pesticides and high sediment loads from current irrigation practices. In Kura River, the concentration of phenols exceeds by 5 times, metals 4 times higher, mineral oil and sulphates in water is twice higher than sanitary norm. The average annual concentration of dissolved oxygen largely exceeding the MAC (maximum allowable concentration) is 7.6 -7.9 mg/l in Kura and Araz rivers.

The average annual concentration of Biological Oxygen Demand (BOD5) in the Kura and Araz monitoring stations is reached to 3 mg/l. Ammonium (NH4+) concentration for rivers averagely are 0.39 mg/l. During the monitoring average, annual concentration of zinc (Zn) was observed in Kura Zardab at 3.89 mg/l, in Aras Novruzlu at 7.92 mg/l, in Kura Surra at 17.5 mg/l. The MACs for Zn in rivers was 10 mg/l (Mammadov et al., 2021).

The statistical data (Table 14) demonstrates an increase of the nutrient content in the fresh water bodies (SSC, 2023, 4).

Table 14. Trend in nutrients in fresh water

Years	2005	2010	2015	2019	2020	2021	2022
Nitrate concentration, mq NO_3/l							
In the rivers:							
Kur	0.53	3.72	1.93	4.13	3.50	6,62	4.50
Araz	0.33	4.07	6.70	1.15	3.00	2,85	3.50
In the lakes:							
Boyuk Shor	0.68	12.00	2.08	-	13.40	2,90	3.70
Hacıhasan	2.71	5.30	1.94	8.20	10.80	4.50	5.50
Masazır	4.06	8.85	5.30	10.00	3.40	9.30	10.40
Yasamal	0.17	0.30	1.88	4.70	3.60	1.70	2.60
Kurdakhanı	5.42	6.90	7.03	10.20	3.60	3.10	3.00
Bulbula	0.28	6.90	2.31	5.80	7.00	3.11	8.20
Phosphorous concentration, mg P/l							
In the rivers:							
Kur	0.03	0.04	0.11	0.06	0.04	0.06	0.06
Araz	0.06	0.05	0.13	0.26	0.23	0.06	0.08
In the lakes:							
Boyuk Shor	0.59	1.01	1.86	-	0.99	1.20	0.60
Hacıhasan	0.42	0.45	2.50	1.48	0.28	0.46	1.1
Masazır	0.27	0.19	0.90	0.40	0.10	0.52	0.90
Yasamal	0.31	0.04	0.71	0.21	0.31	0.37	0.30
Kurdakhanı	0.15	0.50	0.68	0.40	1.70	0.36	0.40
Bulbula	3.36	1.15	2.63	1.70	0.11	0.66	2.00

The construction of collectors and wastewater treatment facilities is planned for the management of wastewater generated in the cities located along the Kura River. Recently, collectors and sewerage water treatment facilities have already been built in Agstafa, Gazakh, Tovuz towns.

In Azerbaijan, systematic monitoring of surface water pollution has been carried out since 1966. Currently, these observations cover 44 water bodies, including 30 rivers, 9 lakes, 4 reservoirs and 1 port. In both Kura and Araz main transboundary rivers, operational monitoring was organized based on the guidelines on "Monitoring and Evaluation of Transboundary Watercourses and International Lakes" developed by a team of qualified UNECE experts (Finnish Environment Institute, 2003). The water laboratories equipped with the required devices and equipment were established in Gazakh and Beylagan regions to monitor these rivers and their cross-border tributaries. Gazakh water laboratory conducts analysis of the water samples taken from the 5 observation points to check transboundary pollution of Kura River. Horadiz water laboratory analyzes water samples taken at 3 observation points to check transboundary pollution of the Araz River. Neftchala Regional Complex Monitoring Laboratory was established in 2019 to monitor the mouth of the Kura River. This laboratory conducts analysis of water, precipitation and soil samples brought from Neftchala and other surrounding areas. After taking samples from water bodies and conducting preliminary analyses, they are sent to the Laboratory Center for basic chemical analysis. This center, analyzes about 17,000 water samples per year for more than 50 indicators (NHC, 2024: 3).

The future protection of the basin water resources is required to establish constructive cooperation between the riparian transboundary countries.

Azerbaijan, as a member of the international community, has joined several conventions and agreements aimed at facilitating transboundary cooperation with the riparian countries. Among basin countries, Azerbaijan became the first country to sign the "Convention on the Protection and Use of Transboundary Watercourses and International Lakes (Water Convention)" in 2000 (UNECE, 1992; GoA, 2000). This convention, adopted under the auspices of the United Nations Economic Commission for Europe (UNECE), promotes cooperation on the management of transboundary water resources. It establishes principles and mechanisms for joint management, risk prevention, and dispute resolution related to shared watercourses and international lakes. In 2014, Azerbaijan and Georgia signed an integrated water resources management program. The overall goal of the program is to develop joint river basin management plans for the transboundary catchment, which is consistent with the objectives of the currently developing Transboundary Agreement on "Co-operation in the field of protection and sustainable use of the water resources in the Kura River basin". This program includes implementation of the targeted activities to achieve short-term, medium-term and long-term goals. Transboundary water management activities under the above Agreement will be coordinated and implemented by the Joint Commission on Sustainable Use and Protection of the Kura River Basin. The Commission is planned to be composed of representatives of competent ministries and agencies of the two countries, as well as representatives of local authorities and competent NGOs (Strosser et al, 2017).

Agreement on cooperation between Azerbaijan and Russia for the efficient use and protection of water resources of the Samur Transboundary River was signed in 2010. According to this document, the water entering the border area of the river is divided equally between the states, excluding 30.5% of environmental flows from the total volume of river water (GoA, 2010).

Agreement on cooperation construction, use of energy and water resources of

Khudaferin and Qizqalasi hydro-junctions and Hydropower Plants on the Araz River between Azerbaijan and Iran was signed in 2016, it stipulated on the equal use of the river water resources (GoA, 2016:2). In 2020, the draft Agreement on cooperation in the field of protection and sustainable use of water resources of the Kura River basin between Azerbaijan, Türkiye and Georgia was prepared to initiate future negotiations and adoption of this document.

The management of the Kura-Araz River basin needs to be jointly considered in terms of establishing rules and accepting international norms (Mohammed Alipour, 2023). These efforts are made, and shall continue to further the cooperation, for the benefits of all basin countries.

Azerbaijan and Georgia also drafted a joint action plan for the protection of the Kura River basin and sustainable management of water resources (RIA, 2024).

Several projects were implemented in the field of cooperation, such as the Kura Basin Joint Water use and Protection (UNDP, 2014). In 2016, a major EU-funded project, the European Union Water Initiative Plus (EUWI+), was implemented to help strengthen water management in Azerbaijan and the five other EaP countries. The project supports bringing their legislation closer to EU policy in the field of water management, with a focus on the management of transboundary river basins. It supports the development and realization of pilot river basin management plans, building on the improved policy framework and ensuring a strong participation of local stakeholders (Mammadov et al, 2021). Along the other tasks, the project supported finalization of bilateral agreement with Georgia. Although no agreement has been reached to date, the countries have a clear understanding of the transboundary issues (OECD, 2022).

Deepening of the transboundary cooperation finally will serve protection of the river ecosystem, health of the environment and humans in the riparian countries.

5.3. Caspian Sea waters and protection

The Caspian Sea is important for Azerbaijan from a socio-economic and environmental point of view. The sea hydrocarbon reserves contribute to the country's energy security. Caspian states and foreign corporations are also actively involved in the extraction of hydrocarbon resources of the sea. Fish resources are also valuable food for the population, but especially in recent years they have declined significantly due to sea pollution, sea water table changes and other reasons. The ten important cities are located at the sea coastal area, including Baku, Sumqayıt and Lenkoran. The total population living in the coastal area in 2023 is 3.68 million or 36.4% of the country's total population (SSC, 2024).

The situation in other sectors of the Caspian Sea is not much different. Oil pollution, wastewater discharges, and illegal fishing are the main factors influencing the reduction of fish resources. In addition, the reduction of rivers flowing into the Caspian Sea and the construction of numerous dams on the rivers are the main factors leading the reduction of marine resources (Abbasov et al, 2022: 1).

Starting from 1978, the level of the Caspian Sea increased at an average rate of 15 cm/year and reached the 2.50m higher than in 1977. Since 2005, there observed a decreasing in the water level of the Caspian Sea. This can have a negative impact on desertification, shipping and other economic activities in coastal areas.

To protect the marine environment from pollution, protection, conservation, restoration, sustainable and rational use of sea biological resources, the *Framework Convention for the Protection of the Marine Environment of the Caspian Sea* was signed in 2003 by all five littoral countries. In Azerbaijan it came into force on April 04, 2006 (GoA, 2006: 2).

The *Convention on the Legal Status of the Caspian Sea*, signed by the five littoral states on 12 August, 2018, which regulates legal aspects, determine and regulate obligations of the littoral states regarding the use of the Caspian Sea, including the waters, bottom, bosom, natural resources and the airspace above (GoA, 2018:1).

The Caspian Complex Ecological Monitoring Department of MENR provides regular monitoring in the beach areas and conducts chemical, biological, ecotoxicological, microbiological examinations defining all kinds of pollutions and takes measures.

Azerbaijan continues to work towards the joint integrated measures and efforts with other littoral states for the protection and ecological health of the Caspian Sea. Specifically, to prevent the direct discharge of wastewater into the sea, in recent years, treatment facilities have been built and put into operation in coastal settlements, and measures for keeping coastal areas and sea waters clean are continued. The scientific-research works have been conducted to improve sea environment monitoring system (Ragiomova et al., 2020).

CHAPTER 6. CONCLUSION AND POLICY RECOMMENDATIONS

6.1. Water security platform outline

The water resources of Azerbaijan have been exposed to the significant changes in quantity and quality due to the ongoing temperature rise and recent climate changes. Therefore, necessary integrated mitigation and adaptation measures have been adopted and realized to address experienced challenges in water resource use and protection. Future development of the country depends on availability of water resources and their management quality to satisfy the needs of the economic branches and ecological safety of all fresh water sources.

In the coming years, the Azerbaijan's water security platform shall seek to address the following strategic plans:

-Drought Management to improve capacity in the droughts and their consequences;

- Reservoir Safety and Flood Risk Management;

-Modernization of water management systems for optimized management of main reservoirs and reduction of downstream losses;

-Soil Salinity Management to prevent degradation of land and water resources and to protect clean water sources and agricultural lands;

-Irrigation Modernization by application of the advanced technologies in irrigated agriculture;

-Water Supply, and Improvement of Sanitation Services for expansion of drinking water treatment and sanitation services in residential and rural areas, and improvement program for these services.

In this context, the protection of water basins should be strengthened, measures to combat the pollution and depletion of water resources due to inefficient use should be expanded (WB, 2020).

Considering the real situation, the preparation of a draft Water Strategy for the country is included in the Action Plan (GoA, 2020: 2) to address all aspects of water-related problems, work out and realize integrated actions to overcome all the predicted challenges to provide the country with sustainable development under the continuous climate changes.

6.2. National Water Strategy for upcoming period

The *National Strategy on the Efficient Use of Water Resources in Azerbaijan (NWS)* was adopted on late 2024 for the coming period. This strategic document covers all aspects of water management in the coming years, the implementation of which is aimed to contribute formation of a healthy attitude towards water resources in society, ensuring their careful consumption, protecting the environment, mitigating the effects of climate change and satisfying the needs of water users, thus accelerating the country's development (GoA, 2024, 5).

The NWS, covering the period from 2024 to 2040, sets out a three-phase plan.

The first phase (2024-2027) focuses on the modernization of water infrastructure and management, the reassessment and expansion of water resources, and the integrated management of water in the Karabakh and Eastern Zangezur economic regions. During this phase, projects will be implemented to improve the quality of water, manage waste and rainwater, expand water facilities, and reduce water losses.

The second phase (2028-2030) aims to strengthen the basic conditions for sustainable water management, aligning with the United Nations' Sustainable Development Goals such as "Clean Water and Sanitation," "Climate Action," and "Life Below Water."

The final phase (2031-2040) will focus on effectively managing hydro-ecological crises through innovative technologies, expanding the use of alternative water sources, and ensuring sustainable access to high-quality water.

The NWS outlines plan for the construction of new reservoirs, the development of smart water management systems, and increased use of desalination and recycled water. It also emphasizes the need for cross-border cooperation on water management, especially with neighboring countries such as Türkiye, Georgia, Russia, and Iran.

The document highlighted the importance of adapting to global climate trends and addressing regional water challenges as key components of the strategy. The initiative is expected to boost Azerbaijan's resilience to climate change and support sustainable agricultural development, energy security, and environmental protection.

The adopted document contains *Action Plan* for Implementation of the NWS during 2024-2027 with the following priorities and objectives:

Priority 1. Improvement of water resources assessment and forecasting system

Objective 1.1. Reassessment of water resources

Objective 1.2. Predicting the impact of climate change on water resources

Objective 1.3. Simulation and digitization of risks on water resources

Priority 2. Efficient management of water resources

Objective 2.1. Formation of an advanced management model

Objective 2.2. Integrated management of water resources

Objective 2.3. Investment management and tariff differentiation

Objective 2.4. Institutional capacity building

Priority 3. Efficient use of water resources

Objective 3.1. Reducing water losses

Objective 3.2. Increasing water resources and using alternative water sources

Objective 3.3. Expansion of water infrastructure

Objective 3.4. Promoting efficient use of water

Objective 3.5. Meeting the demand for water

Priority 4. Ensuring water security

Objective 4.1. Improvement of transboundary and transit water management

Objective 4.2. Strengthening the protection of water bodies

Objective 4.3. Ensuring water quality

Objective 4.4. Adaptation to climate change

Priority 5. Using the water resources potential of Karabakh and East Zangezur economic regions

Objective 5.1. Development of "smart water" systems

Objective 5.2. Use of surface water for hydropower generation

Objective 5.3. Water resources potential - inter-basin water transfer

The relevant responsible government agencies appointed for the implementation of the adopted Action Plan.

The WC is requested annually submit development on the executed works included into the Action Plan to the President of the country, with funding attracted from the state budget, private investments, and international financial institutions. The approval of the NWS marks a significant step in Azerbaijan's efforts to secure its water future amid growing concerns over water scarcity and climate change impacts.

The monitoring and evaluation of the measures stipulated by the NWS will be carried out by the Center for Analysis & Communication of Economic Reforms.

6.3. Water use in agriculture – agri-environmental approach

In Azerbaijan as the main water consumer is irrigation, adaptation of agriculture production under the resource scarcity shall be urgently addressed for the upcoming years for sustainable regional development.

The use of water for irrigation is not only just resource consumption, but it has significant influence on the water and land ecosystems. Therefore, the area of irrigated lands and water use in agriculture is accepted as the main agri-environment indicators in EU (Eurostat, 2018; Eurostat, 2024).

Approximately 90% of the water taken in the country is used for the needs of the agriculture; therefore, water abstraction in agriculture as an agri-environmental indicator, directly has an influence on the water policy in Azerbaijan and guides the process of sector reforms, as well as elaboration of the short and long-term investments.

The runoff of return water (containing fertilizers) from irrigated areas and collector-drainage water into the Kura River and its tributaries affected river water quality. The infiltrated irrigation water dissolve pesticide and fertilizers and finally discharges into the water bodies, polluting water ecosystems and damaging to the fish health. In the last 40 years, Kura water mineralization at Salyan gage increased more than threefold, reaching, on average, 1.0 g/l. In the same period, river water mineralization in the Araz River at Saatli gage increased from 0.4 to 1.3 g/l. Water mineralization in the Kura downstream of the Aras water inflow (Surra gage) increased to 0.8–1.2 g/litre (Aslanov,2013).

Trends in the dynamics of the irrigated area give a clear picture on the intensity of irrigation application in the certain area, agriculture development investments, implemented policies, the efficiency of farming practices, soil quality, salinity, water use, losses in irrigation and ground water quality, and finally ecosystem changes. Most of the irrigated areas in the country are in territories with mineralized groundwater, which water table is close to the soil surface. Therefore, irrigation is executed with the application of the drainage system. For this reason, proper control of the soil's salt-water balance is important to prevent a second type of salinization and loosing of the soil fertility. Water abstraction strongly affects the ecologic flow regime, therefore special care must be taken when abstracting water to maintain the amount of water needed to sustain the health of the ecosystem. Water abstraction in agriculture depends largely on the crop pattern (crop water requirement), the technical and engineering condition of hydraulic structures, irrigation systems as well as applied irrigation technologies and methods. The main problem of water abstraction for agriculture is unproductive water losses and their control.

Considering the environmental impacts of the water and land use in agriculture, for better tracking and understanding of the on-going processes, occurring from farming practices, agri-environmental indicators monitoring system (AEIMS) has been developed in the country for the six indictors, including three water related indicators- water abstraction in agriculture, irrigated area, water contamination. The system consists of a set of the data for monitoring; reporting and verification of digital system, to work out needed measures for the decision makers to improve the situation based on the existing data analyses (Rzayev & Shirinov, 2021; Septem Tech & Destec Group, 2022). Timely monitoring, and precise irrigation water application leads to precise fertilizer use and pest control to avoid soil and underground water pollution.

Thus, in the coming period, it is necessary to establish a comprehensive monitoring system of water use starting from the farm level. The main principle must be observed from the point of view that in case of the water shortage, irrigation planning should be carried out based on the availability of water resources and using advanced irrigation technologies only, for better water management at field and elimination of the unproductive losses.

6.4. Transboundary cooperation for sustainable water use and environmental protection

The United Nations General Assembly Resolution No. 64/292 dated July 28, 2010 clearly indicated the right of everybody, to access to water and sanitation, and it was recognized that clean drinking water and sanitation is essential for the human right (UN, 2010).

Several preconditions are required to facilitate transboundary water management at basin level. There shall be an exchange of information on the quantity, quality and use of water between riparian countries. The parties must regularly provide mutual data to each other on the quality and quantity of the basin waters, the state of the water environment, the occurred changes in the water environment, all other relevant and available information on water withdrawals and pollution sources.

To determine potentials of the opportunities and priorities in transboundary water management, it is necessary to conduct a comprehensive analysis of the exchange of basic data. Appropriate legal and institutional frameworks are advisable to be established for economic, social, and environmental analysis for the realization of the required measures.

The gaps in Kura River basin transboundary water management include the absence of appropriate legislative framework and special intergovernmental institutions. Transboundary water management issues are still not fully explored. There is lack of basic information and monitoring on water quality and quantity, information exchange system network among the countries. The potential of underestimating the economic benefits of cross-border cooperation has not yet been fully analyzed.

According to the Helsinki Rules for the Use of the Waters of International Rivers, adopted by the International Law Union (ILA) in 1966, the distribution of water resources of rivers, that flow nationally and associated groundwater among the basin states should be based on the principles of the equal distribution of river flow, excluding environmental discharges, proportional distribution of water resources to catchment areas as well as distribution of river waters based on interstates' mutual agreements.

The states which have joined the Water Convention shall undertake targeted actions to eliminate or minimize any negative impact on transboundary waters. The water use should be controlled properly to prevent any difficulties in future use, and management measures are recommended to be planned on a basin-wide scale. The river basin should be considered not only as a natural object that satisfies the economic interests of states, but also as a habitat of various living organisms and vegetation. Thus, the river and its basin should be evaluated as a single ecosystem and considered in the use of its resources.

During the upcoming period water inflow into the country is expected to decline more because of the predicted climate changes and an increase in water use in other countries of the Kura–Araz river basin. Changes in the chemistry and an increase in the mineralization of the irrigation water, over the recent half century take place both before water enters the country, in the upper reach of the Kura, and, partly, within the country, due to the current irrigation practices at all levels, and pollution arisen from the untreated sewage waters (Rzayev, 2017: 1). Therefore, transboundary rivers flow management requires coordinated joint measures of all riparian basin countries.

A draft Agreement on cooperation between Azerbaijan, Türkiye and Georgia in the field of protection and sustainable use of water resources of the Kura River basin has been prepared and this document is currently under consideration (WC, 2021).

Thus, the acceleration of the transboundary cooperation within the involved riparian countries is necessary to be deepened forward to the solving of the observed challenges, including decrease and gradual elimination of the water pollution, flood control, mitigation from the landslides and mudflows in all countries. The activities can include joint management plans, projects, research works, preparation of the common guidelines; data exchange on hydrological, meteorological, and environmental data, targeted environmental assessment aiming at restoration of the aquatic ecosystems and protecting biodiversity in all transboundary rivers. The coordination of all activities that jointly protects river ecosystems and avoiding pollution of the rivers shall be a priority policy in all riparian countries. In this regard, the establishment of the institutional framework for sustainable and long-term multilateral collaboration among all countries in the basin would be a suitable tool to accelerate the issues above. The dialogue initiatives will facilitate the transfer of knowledge, skills, values, and principles, as well as gradual legal formulation in all interested states (Mohammad Alipour, 2023).

6.5. Green World Solidarity and Azerbaijan

In Azerbaijan, 2024 has been declared the "Green World Year of Solidarity", demonstrating Azerbaijan's commitment to environmental and climate actions, including policies for protecting water resources and ecosystems.

Within the UN Framework Convention on Climate Change, Azerbaijan regularly submits updated reports of the country which includes; information about the country, GHG inventory results, climate change mitigation analyses, financial and capacity building assessments and domestic MRV systems (GoA,2014: 2; GoA,2018: 2). The national reports are periodically prepared for assessment of the progress and the implementation of the national targets in the field of conservation and sustainable use of biodiversity, including water bodies in Azerbaijan (GoA, 2019: 4).

Understanding the importance of protecting the environment, Azerbaijan is taking steps and efforts towards initiatives to preserve its natural water resources, landscapes, develop renewable energy sources and address pollution problems. As known, the Conference of the Parties (COP) is the supreme decision-making body of the United Nations Framework Convention on Climate Change (UNFCCC), and it convenes annually to assess progress in dealing with climate change and to negotiate the next steps.

Azerbaijan is hosting COP29 in 2024, which will facilitate international cooperation on climate-related issues, including in the field of protection, use and management of water resources. The participation of all relevant stakeholders, including governments, international organizations, NGOs and the private sector, will help focus on the larger issues of climate change and its impact on the quantity and quality of water resources. This will include continuing the key priorities identified during previous discussions in water resources. The upcoming event will provide a unique opportunity to strengthen partnerships with other countries, share best practices and explore opportunities for joint action on all issues of climate change resilience, including water resource management and the sustainable provision of clean water and sanitation for all, including in rural areas. It will also facilitate capacity building among national and international stakeholders, leading to improved understanding and cooperation on environmental issues and serve as a platform for promoting sustainable practices in water management, sanitation, and other environmental areas (CAIR, 2024).

Overall, hosting COP29 in Baku will provide a unique opportunity for Azerbaijan to advance its agenda based on more pressing issues and make proposals on domestic and transboundary water management and access to sanitation. Thus, it is expected that the planned water related activities will bring tangible benefits to the environment and deepen international cooperation on the protection of water resources between countries in the region.

References

1. Abbasov, R., Karimov, R., & Jafarova, N. (2022,1). The Caspian Sea and its values in Azerbaijan. In Ecosystem Services in Azerbaijan: Value and Losses (pp. 1-28). Cham: Springer International Publishing. https://link.springer.com/book/10.1007/978-3-031-08770-7

2. Abbasov, R., Karimov, R., & Jafarova, N. (2022,2). Ecosystem and socioeconomic values of clean water. In Ecosystem Services in Azerbaijan: Value and Losses (pp. 71-121). Cham: Springer International Publishing.

3. ADB (2020). Azerbaijan: Irrigation and Drainage System Development in Nakhchivan Autonomous Republic. https://www.adb.org/projects/53098-002/main

4. Ahmadzade A.& Hashimov A. Encyclopedia. Amelioration and Water Economy (Melorasiya və Su Təsərrüfatı Ensiklopediyası). Baku, Radius, 632 p., 2016.

5. Anh, N. T., Nhan, N. T., Schmalz, B., & Le Luu, T. (2023). Influences of key factors on river water quality in urban and rural areas: A review. Case Studies in Chemical and Environmental Engineering, 100424. https://www.researchgate.net/publication/372552064_Influences_of_key_ factors_on_river_water_quality_in_urban_and_rural_areas_A_review

6. Asadov A. (2023). Speech from the conference "20 years of impeccable service to the country, people and state". Information from the press service of the Cabinet of Ministers. https://nk.gov.az/az/xeberler/matbuat-xidmatinin-malumati/vetene-xalqa-ve-dovletciliye-misilsiz-xidmetin-20-2981

7. Aslanov, H. (2013). Eco-geographic problems of the lower reaches of the Kura River. (In Azerbaijani language). Baku: Chashyoglu, 2013. http://anl.az/el/Kitab/2014/Azf-276462.pdf

8. AAWM (2022). Consolidated Financial statements and Auditor's report as of 12.31.2022. https://mst.gov.az/az/maliyye_hesabati

9. Azerbaijan Geographical Society (2024). The rivers of Azerbaijan. Article. https://gsaz.az/articles/view/108/Azarbaycanin-chaylari

10. Atayev, Z.V., Gadzhibekov, M. I., & Abdullayev, K. A. (2021). Ecological state of the Samur River basin in connection with pollution by plastic and other solid household waste (Экологическое состояние бассейна реки самур в связи с загрязнением пластиковыми и другими твердыми бытовыми отходами. Отчет о выполнении научно-исследовательской работы, 140 с.). https://www.researchgate.net/publication/357312263_Ekologiceskoe_sostoanie_ bassejna_reki_Samur

11. ASWRA (2023, 1). New drinking and waste water networks are being created in Neftchala city. https://azersu.az/en/blog/3121

12. ASWRA (2023, 2). Regulation of Azerbaijan State Water Resources Agency. https://president.az/az/articles/view/62242

13. ASWRA (2024). Baku Water Week 2024: A Vital Confluence of Industry Leaders. https://ica-events.com/media/news/baku-waterweek-2024

14. ASWRA (2024,1). New drinking and waste water systems were commissioned in 2023. https://azersu.az/en/blog/3211

15. Azersu JSC (2022). Consolidated financial statements of Azersu OJSC for 2022. Materials of Azersu JSC. https://azersu.az/az/static/45/files

16. Czech K. (2018). Oil dependence of post-Soviet countries in the Caspian Sea Region: the case of Azerbaijan and Kazakhstan. Acta Scientiarum Polonorum. Oeconomia, 17(3), 5-12. https://doi.org/10.22630/ASPE.2018.17.3.32

17. CoM (2023). Annual water economy balance of the Republic of Azerbaijan. Approved by the Decree No. 755 of the Cabinet of Ministers of the Republic of Azerbaijan on September 05, 2023.

18. CWIF (2023). Concept message "Water for the future". Caspian Water Innovation Forum. https://wif.az/

19. Eurostat (2018). Agri-environmental indicator - water abstraction. https://ec.europa.eu/eurostat/statistics-explained/index.php/Archive:Agri-environmental_indicator_-_water_abstraction

20. Eurostat (2024). Agri-environmental indicator – irrigation. https://ec.europa.eu/eurostat/ statistics-explained/index.php/Agri-environmental_indicator_-_irrigation#Analysis_at_EU_and_country_level

21. EUWI (2021). Technical Report pressure & impact analysis of the transitional and coastal water bodies in the Kura river delta including the eastern part of the Kura-Araz river basin in Azerbaijan, p.19. https://euwipluseast.eu/images/2021/11/AZ_PI_Kura_delta_July21.pdf

22. Finnish Environment Institute (2003). Finnish Guidelines on Monitoring and Assessment of Transboundary and International Lakes. UNECE Working Group on Monitoring and Assessment. https://unece.org/DAM/env/water/publications/assessment/lakestechnicaldoc.pdf

23. Gabrielyan, A. V., Shahnazaryan, G. A., & Minasyan, S. H. (2018). Distribution and identification of sources of heavy metals in the Voghji River basin impacted by mining activities (Armenia). Journal of Chemistry, 2018(1), 7172426. https://onlinelibrary.wiley.com/doi/epdf/ 10.1155/2018/7172426

24. Gurgenidze, D., & Romanovski, V. (2023). The Pharmaceutical Pollution of Water Resources Using the Example of the Kura River (Tbilisi, Georgia). Water, 15(14), 2574.

25. GoA (1995). On the rules of maintaining the state water cadastre. Resolution of the CoM No 336 from December 5, 1995. Legislative Collection of the Republic of Azerbaijan, 2005, No. 1, Article 49. https://e-qanun.az/framework/28153

26. GoA (1996). Law on Amelioration and Irrigation. Legislative Collection of the Republic of Azerbaijan, 1997, No. 3, Article 170. http://www.e-qanun.az/framework/4170

27. GOA (1998). Water Code of Azerbaijan. Legislative collection of the Republic of Azerbaijan, 1998, No. 3, Article 135.

28. GoA (1999). Law on Water Supply and Wastewater. Legislative Collection of the Republic of Azerbaijan, 2000, No. 1, Article 2. https://e-qanun.az/framework/74#_edn1

29. GoA (2000). Law of the Republic of Azerbaijan on joining the United Nations Convention "On the Protection and Use of Transboundary Watercourses and International Lakes". https://e-qanun.az/framework/647

30. GoA (2002). Law of the Republic of Azerbaijan on the safety of hydraulic structures. Legislative Collection of the Republic of Azerbaijan, 2003, No. 2, Article 78.

31. GoA (2005). The rules on the conditions of transfer of state amelioration and irrigation systems located in the WUUs service areas for long-term usage and hand over back in case of breach of these conditions, Contract form for water supply services between Azerbaijan AWM OJSC and WUUs, and Annual Agreement form according to the contract on water supply services between Azerbaijan AWM OJSC and WUUs. Resolution of the Cabinet of Ministries of the Republic of Azerbaijan No. 138. Collection of Laws of the Republic of Azerbaijan, No 7 (97), Article 671, Qanun: Baku, Baku: Azerbaijan publishing house, 2005, pp. 1973-1977. http://www.e-qanun.az/framework/10561

32. GoA (2006,1). About the tariffs of paid water use services provided by Azerbaijan Reclamation and Water Management Open Joint Stock Company. Resolution of the Tariff (Price) Council of the Republic of Azerbaijan No 6, April 12, 2006. https://e-qanun.az/framework/15693

33. GoA (2006,2). Law the Republic of Azerbaijan on approval of Framework Convention for the Protection of the Marine Environment of the Caspian Sea. https://e-qanun.az/framework/11556

34. GoA (2010). Law of the Republic of Azerbaijan on the approval of the Agreement "On cooperation between the Government of the Republic of Azerbaijan and the Government of the Russian Federation in the field of effective use and protection of water resources of the Samur transboundary river". https://e-qanun.az/framework/21179

35. GoA (2014,1). Rules for water use. Legislative Collection of the Republic of Azerbaijan, 2014, No. 7, Article 950. https://e-qanun.az/framework/28153

36. GoA (2014,2). The First Biennial Updated Report of the Republic of Azerbaijan to the UN Framework Convention on Climate Change. Submitted in accordance with the UN Framework Convention on Climate Change Conference of the Parties (COP) Decision 1/CP.16. https://unfccc.int/resource/docs/natc/aze_bur1_eng.pdf

37. GoA (2016,1). Strategic roadmap on production and processing of agricultural products in Azerbaijan. Decree of the President of the Republic of Azerbaijan "On approval of the strategic road maps for the national economy and main economic sectors" dated 06 December 2016. https://mst.gov.az/assets/upload/files/Strateji%20yol%20xeritesi-Kend%20teserrufati.pdf

38. GoA (2016, 2). Law of the Republic of Azerbaijan "On the approval of the Agreement between the Government of the Republic of Azerbaijan and the Government of the Islamic Republic of Iran on the continuation of the construction, operation, and cooperation in the field of energy and water resources use of the "Khudafarin" and "Giz Galasi" hydroelectric stations and hydropower stations on the Araz River". https://e-qanun.az/framework/33288

39. GoA (2018,1). Law of the Republic of Azerbaijan on approval of Convention on the Legal Status of the Caspian Sea. https://e-qanun.az/framework/41551

40. GoA (2018,2). Second Biennial Update Report of the Republic of Azerbaijan to UN Framework Convention on Climate Change. Submitted in accordance with the decision no. 1/CP.16 of the Conference of Parties of UN Framework Convention on Climate Change. https://unfccc.int/sites/default/files/resource/Second%20Biennial%20Update%20Report%20-%20Azerbaijan-version%20for%20submission.pdf

41. GoA (2019, 1). Regulations on "Electronic agriculture" information system. Legislative Collection of the Republic of Azerbaijan, 2019, No. 12, Article 1940. http://e-qanun.az/framework/43940

42. GoA (2019, 2). Rules "On compilation of water management balances for the republic, water basins and administrative-territorial units. http://www.e-qanun.az/framework/42263

43. GoA (2019,3). State program of socio-economic development of the regions of the Republic of Azerbaijan in 2019-2023. Legislative Collection of the Republic of Azerbaijan, 2019, No. 1, Article 90. https://e-qanun.az/framework/41320

44. GoA (2019,4). Sixth National Report on the Conservation of Biological Diversity. https://www.cbd.int/doc/nr/nr-06/az-nr-06-en.pdf

45. GoA (2020,1). Degree of the President of AR "On the measures to ensure efficient use of water resources. https://president.az/az/articles/view/36558

46. GoA (2020,2). Degree of the President of AR "On additional measures to ensure the efficient use of water resources. Legislative Collection of the Republic of Azerbaijan, 2020, No. 7, Article 942.

47. GOA (2021,1). Regulation on the "Electronic water management" information system. Legislative Collection of the Republic of Azerbaijan, 2021, No. 2, Article 131. https://e-qanun.az/framework/46872

48. GoA (2021,2). Azerbaijan 2030: National Priorities for Socio-Economic Development. Decree of the President of the Republic of Azerbaijan dated February 2, 2021. Legislative Collection of the Republic of Azerbaijan, 2021, No. 2, Article 135. https://e-qanun.az/framework/46813

49. GoA (2022,1). Rules on paid use of water in the Republic of Azerbaijan. Approved by the Decision Cabinet of Ministers of the Republic of Azerbaijan No. 95, March 17, 2022. https://e-qanun.az/framework/49311

50. GoA (2022,2). Law of the Republic of Azerbaijan "On the State Budget of the Republic of Azerbaijan for 2023". Legislative Collection of the Republic of Azerbaijan, 2022, No. 12, Article 1380.

51. GoA (2022,3). I State Program on the Great Return to the liberated territories of the Republic of Azerbaijan. Legislative Collection of the Republic of Azerbaijan, 2022, No. 7, Article 793 (Volume I)]. https://e-qanun.az/framework/52757

52. GoA (2022,4). Law on Public-Private Partnership. https://e-qanun.az/framework/53020

53. GoA (2023,1). Degree of President of the AR "On the improvement of management in the areas of water resources, water management and reclamation". Legislative Collection of the Republic of Azerbaijan, 2023, No. 3, Article 370. https://e-qanun.az/framework/53813

54. GoA (2023,2). Decree of the President of the Republic of Azerbaijan on a number of measures related to ensuring the activities of the State Water Resources Agency of Azerbaijan. https://president.az/az/articles/view/62241

55. GoA (2023,3). Law of the Republic of Azerbaijan "On the State Budget of the Republic of Azerbaijan for 2024"No. Legislative Collection of the Republic of Azerbaijan, 2023, No. 12 (Book I), Article 1685

56. GoA (2023,4). About measures for the implementation of the pilot project in the field of drinking water production through desalination of sea water. Order of President of the Republic of Azerbaijan from 12 April 2023. https://e-qanun.az/framework/53907

57. GoA (2023,5). On measures for the implementation of the pilot project related to the treatment and reuse of wastewater discharged from the Hovsan aeration plant into the Caspian Sea. Order No 4229 of the President of the Republic of Azerbaijan from 25.12.2023. https://president.az/az/articles/view/62738

58. GoA (2024,1). On ensuring the activities of public legal entities subordinated to the Azerbaijan State Water Resources Agency. Resolution No. 232 of the Cabinet of Ministers of the Republic of Azerbaijan. dated April 26, 2024. https://e-qanun.az/framework/56807

59. GoA (2024,2). Rules on public- private partnership. Decision of the CoM. https://nk.gov.az/az/senedler/qerarlar/dovlet-ozel-terefdasligi-qaydalarinin-tesdiq-edilm-7925

60. GoA (2024,3). On measures related to the reconstruction of the Karabakh irrigation canal. Order of Presidents of Azerbaijan No 85 dated from 15.04.2024. https://e-qanun.az/framework/56711

61. GoA (2024,4). On reconstruction of Shirvan irrigation canal. Order of Presidents of Azerbaijan No 84 dated from 08.04.2024. https://e-qanun.az/framework/56701

62. GoA (2024,5). National Strategy on Efficient Use of Water Resources. Order of the President of the Republic of Azerbaijan dated 10 October 2024. https://static.president.az/upload/Files/2024/10/11/3579828d4b3fb5cd36b497304e510793_1179943.pdf

63. Hasanov S., Abbasov R. (2020). Kura River. "To healthy life" Ecological Public Union. https://www.ecolifeinfo.az/en/kura-river/

64. Huseynov A. (2017). The main rivers composing the water balance of Azerbaijan (Azərbaycaninin su balansini təşkil edən əsas çaylar). Scientific works of the Institute of Microbiology of ANAS, 2017, v. 15, no. 2, p. 6-25.

65. Imanov, F. (2016). Water resources and their use in the transboundary basin of the Kura River (Водные ресурсы и их использование в трансграничном бассейне р. Куры). St. Petersburg: Own Publishing House, 2016,164 p.

66. Ismayilov R. (2021). Evaluation of ecological safety of Azerbaijani rivers (in the example of rivers flowing directly to the Caspian Sea (Azərbaycan çaylarinin ekoloji təhlükəsizliyinin qiymətləndirilməsi). Baku, 2021, p.47. https://www.sukanal.az/wp-content/uploads/2021/06/Rashail-Ismailov.pdf

67. Lomsadze, Z., Makharadze, K., & Pirtskhalava, R. (2016). The ecological problems of rivers of Georgia (the Caspian Sea basin). Annals of agrarian science, 14(3), 237-242.

68. Mamedov R.M & Abdutev M.A(2018). Formation of river water resources of Azerbaijan, their hydrochemical analysis for the purpose of assessing ecological suitability. (Формирование ресурсов речных вод азербайджана, их гидрохимический анализ с целью оценки экологической пригодностию), Водное хозяйство России № 2, 2018, с.19-34. https://waterjournal.ru/files/wj/1572248254.pdf

69. Mammadov R., Aliyev H, Imanov F., Safarov S., Ismailov R., Safarov E., Aliyev H. & Nasibli Y. (2021). Technical report "Pressure & Impact analysis of the transitional and coastal water bodies in the Kura River Delta, including the eastern part of the Kura-Aras River Basin in Azerbaijan. EU Water Initiative Plus (EUWI+) for Eastern Partnership Countries. Project document AVH 10839-AZ-AGS-1, p/19-25. https://euwipluseast.eu/images/2021/11/AZ_PI_Kura_delta_July21.pdf

70. Margaryan L (2017). Impact of mining industries on the quality of the river water (Воздействие горнодобывающих предприятий на качество воды рек. Химическая безопасность). Chimicheskaya bezopasnost, 2017, Volume1, no 1, p.86-91. DOI: 10.25514/ CHS.2017.1.11435. http://old.chemsafety.ru/wp-content/uploads/2018/03/61-Margaryan.pdf

71. Mchedluri, T., Petriashvili, E., & Liliana, T. (2024). Assessment of microbiological pollution in the Khrami River basin. Conferencea, 26-28. https://conferencea.org/index.php/conferences /article/view/3222

72. MENR (2020). Regulation about the Ministry of Ecology and Natural Resources of the Republic of Azerbaijan. https://e-qanun.az/framework/44803

73. MENR (2024,1). Hydrometeorology. Rivers. https://eco.gov.az/az/fealiyyet-istiqametleri/hidrometeorologiya/chaylar

74. MENR (2024). Legislation. https://eco.gov.az/

75. MENR (2024,1). Underground waters. https://eco.gov.az/az/tebii-servetlerimiz/yeralti-sular

76. MoA (2005). Regulation of the Ministry of Agriculture of the Republic of Azerbaijan. https://e-qanun.az/framework/9517

77. Mikayilov Z. (2024). Water managers and land reclamation workers celebrate professional holidays with great pride. Azertag Information Agency. Article. https://azertag.az/xeber /su_teserrufati_ve_meliorasiya_ischileri_pese_bayramini_boyuk_ferehle_qeyd_edir____meqale-3039430

78. Mohammad Alipour, F. (2023). Hybrid Diplomacy in a Nexus Approach; Managing Shared Water Resources in Kura-Aras River Basin. Journal of Iran and Central Eurasia Studies. https://jices.ut.ac.ir/article_95143_cbd3891d6c338712f680b9d1a8034157.pdf

79. Musayev Z.S., Mammadov K.M., M.S. Zarbaliyev (2009). Integrated management of water resources (Su ehtiyatlatlarının inteqrasiyalı idarə olunması. Dərslik). Textbook, Bakı, Tehsil NPM, 2009, 376p. https://anl.az/el/m/mz_seiio.pdf

80. Nagiyev Z. (2021) Water sources of Baku city and Absheron region (Bakı şəhəri və Abşeron rayonunun su mənbələri). Baku 2021, 556 p.

81. NHC (2022). Results of snow measurement work on March 2022, the current state of water in the main rivers of the country and a forecast of expected runoff in the spring-summer (April, May, June) high flow season.

82. NHC (2023). Results of snow measurement work on March 2023, the current state of water in the main rivers of the country and a forecast of expected runoff in the spring-summer (April, May, June) high flow season.

83. NHC (2024,1). Rivers. https://meteo.az/index.php?ln=az&pg=96

84. NHC (2024,2). Results of snow measurement work on March 2024, the current state of water in the main rivers of the country and a forecast of expected runoff in the spring-summer (April, May, June) high flow season.

85. NHC (2024,3). Surface water quality control. https://meteo.az/index.php?ln=az&pg=148

86. OECD,2023. Improving water infrastructure in Azerbaijan using an expenditure support scheme. Program summary. https://www.eu4environment.org/app/uploads/2023/12/ Summary-Improving-water-infrastructure-in-AZE-using-an-expenditure-support-scheme.pdf

87. OECD (2022). Water policy highlights. Azerbaijan. https://issuu.com/oecd.publishing/docs/azerbaijan_euwi_highlights_web-1_

88. President Administration (2023). Ilham Aliyev had a meeting with the heads of leading German companies. https://president.az/az/articles/view/59166

89. Pashayev E. (2021). Risks to water resources and hydrotechnical facilities in de-occupied territories. Emergency risks in liberated territories. Scientific-technical conference materials, p.13-15. Azerbaijan Architecture and Construction university. Baku, May 21-22, 2021. https://azmiu.edu.az/upload/ckeditor/1014100621.pdf

90. Ragimova, N. A., Abdullayev, V. H., & Abbasova, V. S. (2020). Organization of environmental monitoring in the Caspian Sea. ScienceRise, (2 (67)), 3-9.

91. Reed C. (2022). Azerbaijan's water and land resources. J Environ Geol. 2022; 6(2):16-18 https://www.pulsus.com/scholarly-articles/azerbaijans-water-and-land-resources.pdf

92. RIA (2023). Let's not jeopardize our future: let's save a drop. Article. https://report.az/daxili-siyaset/geleceyimizi-tehlukeye-atmayaq-bir-damci-qoruyaq/

93. RIA (2024). Azerbaijan and Georgia have prepared an action plan for the protection of the Kura river basin. https://report.az/ekologiya/kur-cayi-hovzesinin-muhafizesi-ucun-azerbaycan-ve-gurcustan-arasinda-fealiyyet-plani-hazirlanib/

94. Rucevska, I., Yemelin, V., Malashkhia, N., Kirkfeldt, T., Jørstad, H., & Lengyel, Z. (2017). Climate Change and Security in the South Caucasus. Republic of Armenia, Republic of Azerbaijan and Georgia: Regional Assessment, p.80-82. https://www.osce.org/files/f/documents/3/1/355546.pdf

95. Rzayev M (2007). Current irrigation system management features in the Republic of Azerbaijan. Irrigation and Drainage: The Journal of the International Commission on Irrigation and Drainage, 56(5), 551-563.

96. Rzayev M. (2015). Participatory irrigation management practices in Azerbaijan and future development needs. Irrigation and drainage, 64(3), 326-339.

97. Rzayev M. (2017,1). Problems of water protection against adverse impact of irrigated agriculture and approaches to their solution in arid zones. Water resources, 44(1), 158-166.

98. Rzayev M. (2017,2). Rzayev, M. A. O. (2017). Some remarks on the current efforts for future protection of the Kura water resources through trans-boundary cooperation and modernized national policy measures. Int J Hydro, 1(4), p.123-125.

99. Rzayev M. (2023). Measures for the rational use of water resources in the irrigated zones of Azerbaijan under the conditions of climate change (Меры по рациональному использованию водных ресурсов в зонах орошения Азербайджана в условиях изменения климата). Reclamation 2023 No. 4(106) scientific journal. National Academy of Sciences of Belarus, 2023, No 4(106). p.68-42.

100. Rzayev M., & Shirinov G. (2021). Requirement analysis for the establishment of a monitoring system for agri-environmental indicators. Report, 96 p. Management of natural resources and safeguarding of ecosystem services for sustainable rural development in the South Caucasus (ECOserve) Project. Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH.

101. Septem Tech & Destec Group (2022). Development of a monitoring system for agri-environmental indicators (AEIMS). Final Report. Management of natural resources and safeguarding of ecosystem services for sustainable rural development in the South Caucasus (ECOserve). Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH.

102. State Reclamation and Water Management Agency (2005). Model Charter of the Water Use Union. WUU Support Group. Baku, 2005, 23 p.

103. Strosser, P., G. De Paoli & T. Efimova (2017), The Potential Benefits of Transboundary Co-operation in Georgia and Azerbaijan: Kura River Basin", OECD Environment Working Papers, No. 114, OECD Publishing, Paris. https://doi.org/10.1787/a14da8ec-en

104. SSC (2022,1). The area of irrigated lands. https://www.stat.gov.az/source/agriculture/

105. SSC (2022,2). The status of the drinking water supply of population. Statistical collection. Baku, p.6-7.

106. SSC (2023,1). The foreign trade of Azerbaijan. Exports of main commodities in 2022 (by countries). Statistical publication, p.200.

107. SSC (2023,1). Water Resources. In book Environment in Azerbaijan / Statistical yearbook, p. 68-71. Baku, Chashioglu EI MMC.

108. SSC (2023,2). Household amenities and supply. Household survey results. Official publication. Statistical compilation. Baku, 2023 p. 108

109. SSC (2023,3). Sown area under cotton. Agriculture in Azerbaijan https://www.stat.gov.az/source/agriculture/

110. SSC (2023,4). Environment. Basic indicators of the ecological information joint system. Concentration of biogenic substances in fresh water. https://www.stat.gov.az/source/environment/

111. SSC (2024). Demographic indicators of Azerbaijan. Statistical yearbook. Chasioglu-EI MMC publication house.

112. Tagiyev F. (2023, March 30). How to solve the water problem of the Azerbaijani farmer. Oxu.az. https://oxu.az/cemiyyet/azerbaycan-fermerinin-su-problemini-nece-hell-etmek-olar-foto

113. TC (2006). About the tariffs of paid water use services provided by Azerbaijan Reclamation and Water Management Open Joint Stock Company. Decision of the Tariff (Price) Council of the Republic of Azerbaijan. https://e-qanun.az/framework/15693

114. TC (2021). On amendment of the Decision No. 6 of May 13, 2016 of the Tariff (Price) Council of the Republic of Azerbaijan "On Approving the Tariffs of Water Supply and Waste Water Discharge Services". Decision of the Tariff (Price) Council of the Republic of Azerbaijan. https://e-qanun.az/framework/48001

115. UN (2010). Resolution A/RES/64/292. United Nations General Assembly, July 2010. https://www.refworld.org/legal/resolution/unga/2010/en/76535

116. UN (2021). Third Voluntary National Review. the Republic of Azerbaijan. https://sustainabledevelopment.un.org/content/documents/279452021_VNR_Report_Azerbaijan.pdf

117. UN (2022). UN-Azerbaijan. Annual Results Report. https://azerbaijan.un.org/en/268304-un-azerbaijan-annual-results-report-2023

118. UNCCD (2020). National Drought Plan in Azerbaijan. 38 p. https://www.unccd.int/land-and-life/drought/drought-planning

119. UNDP (2013). Updated Transboundary Diagnostic Analysis for Kura–Aras River Basin. UNDP/GEF Project. Reducing Transboundary Degradation in the Kura–Aras R. Basin. Tbilisi, 2013. https://www.undp.org/sites/g/files/zskgke326/files/migration/ge/UNDP_GE_EE_kura-aras_TDA_2013_rus.pdf

120. UNDP (2014). Strategic Action Program for "Reducing Transboundary Degradation in the Kura River Basin". https://iwlearn.net/documents?f=1&q=Kura-Aras&sort=published& pc=1000& pg=1

121. UNECE (1992), Convention on the Protection and Use of Transboundary Watercourses and International Lakes, Helsinki, 17 March 1992. https://unece.org/DAM/ env/water/documents/ brochure_water_convention.pdf

122. Verdiyev A. (2024, 28 February). Task Force on Water and Climate Fourteenth meeting, Geneva, UNECE. https://unece.org/sites/default/files/2024-03/4_3_Verdiyev.pdf

123. WB & ADB (2021). Climate Risk Country Profile: Azerbaijan. World Bank. https://www.adb.org/sites/default/files/publication/707466/climate-risk-country-profile-azerbaijan.pdf

124. WB (2020). Azerbaijan Water Security Diagnostic Report. Unpublished Report, 16p.

125. WC, 2021. Information on strengthening international cooperation in the field of protection and sustainable use of water resources of the Kura River basin. Unpublished. Submitted by the letter of MENR from 19.04.2021.

126. Winston Y, Fraval P., Misra S., Sinha R., Robinson Z. and Huseynov H. (2022). Azerbaijan's water services: Shifting focus from building infrastructure to building institutions. Eurasian Perspectives, WB blogs. https://blogs.worldbank.org/en/europeandcentralasia/azerbaijans-water-services-shifting-focus-building-infrastructure-building

KAZAKHSTAN

List of Abbreviations

OTS	Organization of the Turkic States
AQUASTAT FAO	Statistical Database for Water
ADB	Asian Development Bank
BWAs	Basin Water Authorities
EU	European Union
EIA	Environmental Impact assessment
O&M	Operation and Maintenance
CAP	Common Agricultural Policy
CBD	Convention on Biological Diversity
CIS	Commonwealth of the Independ countries
FAO UN	Food and Agriculture Organization
FAOSTAT FAO	Statistical Database
NME	National Ministry of Economy
Kazvodkhoz	State enterprise on the right of economic management of the Water Management Committee of the Ministry of Water Resources and Irrigation
UNDP	United Nations Development Program
WMC	Water Management Committee of the Ministry of Water Resources and Irrigation of the Republic of Kazakhstan
WB	World Bank

EXECUTIVE SUMMARY

Kazakhstan is characterized by a great variety of natural, climatic and geographical conditions. The main part of its territory is located in the arid zone and has extremely limited water resources. All waters within the state border of Kazakhstan Republic constitute a single water fund, including rivers, lakes, glaciers, reservoirs, as well as other surface water bodies and water sources, main water conduits, canals, underground waters, waters of the Caspian and Aral seas.

Water resources of all river basins are almost completely involved in economic use. The deficit of water consumption is aggravated by high variability of runoff and territorial unevenness of its distribution.

In the central part of Kazakhstan, occupied by desert areas, the main water arteries are low-water springs. To the south, in the foothill and mountainous areas, the density of the river network increases and reaches its greatest development in the southern and southeastern suburbs. The flow of rivers in the southern and eastern zones of the republic is formed by melting ice and snow. The flow of rivers in Northern, Western and Central Kazakhstan is mostly due to winter precipitation. The main phase of the water regime of the rivers of Kazakhstan, except for the southern and southeastern regions, is the spring flood, which accounts for most or all of the annual runoff. Many small rivers dry up and freeze during the summer-autumn and winter seasons.

In order to accumulate winter and spring river runoff in Kazakhstan, 180 reservoirs with a total capacity of 90 x 10^9 m^3 have been constructed, mainly for the purposes of domestic and drinking water supply, energy, and irrigation.

The economy of the country is characterized by developed industrial production and agriculture. The main consumers of fresh water are irrigated agriculture, urban and rural water supply, industry and public utilities.

Water resources management in the country is based on a combination of water-basin and administrative-territorial principles that ensure the protection and reproduction of water resources, optimal conditions of water use, and preservation of environmental sustainability (Kipshakbayev, 2014).

The solution of water problems in Kazakhstan is recognized as one of the most important priorities in the Strategy “Kazakhstan 2050”, and was also voiced in the message of the Head of State from September 1, 2021 “Unity of the People and system reforms - a solid basis for the prosperity of the country: “In the next ten years, the United Nations predicts a global deficit of water resources. By 2030, global water scarcity may reach 40%. Therefore, we need to increase water conservation through the latest technologies and digitalization. This is a strategic task, there is no other way to prevent water scarcity. The government needs to prepare concrete solutions that will incentivize the introduction of water-saving technologies and effectively regulate water consumption" (Tokayev, 2021).

The Republic of Kazakhstan suffers from a lack of water resources, as they are largely dependent on river and lake flows, which are limited by the geographical location of the country. Kazakhstan is highly dependent on neighboring countries such as China, Kyrgyzstan, Uzbekistan, and the Russian Federation for water resources. Rivers passing through these states are the source of feeding many water bodies and water systems important for Kazakhstan. In this regard, Kazakhstan's water policy is based on the principles of international water law, and the country's water legislation recognizes the priority of ratified interstate agreements.

The water legislation of the Republic of Kazakhstan is based on the Constitution of the Republic of Kazakhstan and consists of the Water Code and other normative legal acts of the Republic of Kazakhstan, as well as governmental acts corresponding to this Law that regulate issues of water economy and water resources management. If international treaties ratified by the Republic of Kazakhstan establish other rules than those contained in this Code, the rules of international treaties shall be applied.

Within the framework of the State Program for the development of the agro-industrial complex of the Republic of Kazakhstan during 2017-2021 it was envisaged with the introduction of 9 water-saving irrigation technologies to construct 22 new reservoirs with a total volume of 1.9 x 10^9 m^3 (GoK, 2018). Within the framework of NP "Green Kazakhstan", until 2025, the first stage of construction of 9 reservoirs in 6 provinces of the country with a total volume of 1.7 x 10^9 m^3 is planned, including: Akmola - 1, Almaty - 1, Zhambyl - 3, West Kazakhstan - 2, Kyzylorda - 1, Turkestan - 1 (GoK, 2021).

By 2030, significant improvements are expected in the water sector in the country - reduction of unproductive losses during water transportation, development of hydrogeological and reclamation monitoring system to improve the condition of irrigated lands, improvement of technical condition of hydraulic structures for guaranteed water supply to economic sectors and reduction of threats of emergencies. The determining direction will be the introduction of water-saving irrigation technologies, which will allow saving 20-30% of irrigation water and farm irrigated areas, finally increasing the productivity of water resources use by 2-2.5 times. Increased utilization of treated wastewater will reduce the anthropogenic load on water bodies.

Due to rational use of available water resources, including active introduction of water-saving irrigation technologies, prerequisites will be created for transition from *"resource management"* to *"demand management"*, the main principle of which is to use less water to meet the same needs.

CHAPTER 1. WATER AVAILABILITY, ABSTRACTION, AND WATER DELIVERY

1.1. Available water resources; Water balance

Water deficit is one of the serious problems of the present time and has already led in a number of regions of the world to deterioration of ecological state of natural environment, drying up of lakes and river ecosystems, and growth of population with diseases.

Kazakhstan has limited reserves of renewable water resources in terms of water availability of its territory, which is a serious limiting factor in the development of the richest natural reserves and sustainable and economic development of the environment (Tyumenev, 2008). In the mountain systems of Kazakhstan, there is also a decrease in the number and size of glaciers. According to certain studies, in the next decades, due to global warming, the water resources of the main rivers of Kazakhstan may decrease by 20–40% (Tursunova et al., 2022).

The complexity of the country's water supply problems is determined by the fact that almost half of Kazakhstan's renewable water resources are formed outside its borders. Groundwater is also very unevenly distributed over the territory, and its quality and reserves vary across the country's regions. Fresh groundwater has a number of significant advantages over surface water: as a rule, it is higher in quality, better protected from pollution and contamination, and its resources are less subject to multi-year and seasonal fluctuations.

In general, the Republic of Kazakhstan is sufficiently rich in groundwater, due to which it is possible to fully provide the population with household, drinking, technical and other waters in accordance with the needs of the population, industry and agriculture. Groundwater is available throughout the territory of our country, but it is very unevenly distributed. In addition, the quality and reserves of groundwater vary depending on the region.

Furthermore, socio-economic development of the country and solutions to environmental problems will be determined to a large extent by the state water policy, correct choice of development strategy and management of the country's water sector. The fundamental reforming of the economy, including the water sector, which is taking place in the country, imposes certain requirements to the water policy. Water supply to economic sectors and natural complexes should be carried out in the direction of increasing the available share of natural water resources and their rational use.

The current task of water policy is the basic methods and principles of IWRM (integrated water resources management), their current state and the most complete and economically expedient satisfaction of water users and water consumers' needs, taking into account nature conservation and water protection from pollution and depletion.

The development of the economy of the country, in the context of territorial-industrial complexes, provinces and individual cities, largely depends on the availability of water resources in the country. Surface water resource of Kazakhstan is an average100.5 x 10^9 m^3/year, of which only 56.5 x 10^9 m^3 is formed in the territory of the country. The remaining 44 x 10^9 m^3 inflows are from neighboring states: China 18.9 x 10^9 m^3; Uzbekistan -14.6 x 10^9 m^3; Kyrgyzstan -3 x 10^9 m^3; and Russia -7.5 x 10^9 m^3 (Karimov, 2023).

Kazakhstan ranks last among the countries of CIS in terms of water availability. Specific water availability is equal to 37.000 m^3/km^2 and 6.000 m^3/year for each person (Yespolov et al, 2022).

Due to the climatic peculiarities of different zones of the country, up to 90% of surface water runoff occurs in spring period. In addition, surface water resources are distributed very unevenly over the territory and fluctuate by years and within a year, thereby causing uneven provision of different regions and sectors of the economy. East Kazakhstan oblast is the most supplied with water resources; 290,000 $m^{3/}km^2$. At the same time, Atyrau, Kyzylorda and, especially, Mangistau regions, where fresh water is practically absent, experience water deficit.

According to the hydrographic principle, eight river water basins have been identified in the territory of the country: Aral-Syrdarya, Balkhash-Alakol, Ertis, Yesil, Zhaiyk-Caspian, Nura-Sarysu, Tobyl-Torgai and Shu-Talas.

Accordingly, there are eight basin inspectorates operating in the country to regulate the use and protection of water resources: Aral-Syrdarya, Balkash-Alakol, Ertysk, Yesil, Zhaiyk-Caspian, Nura-Sarysu, Tobol-Torgai and Shu-Talas basin inspectorates (Figure1).

Aral-Syrdarya basin: The Aral-Syrdarya basin covers an area of about 345.000 km^2 and includes two administrative regions-South Kazakhstan and Kyzylorda. The main river of the basin is the Syr Darya River, which originates outside Kazakhstan in the Fergana Valley at the confluence of the Naryn and Karadarya Rivers. The total length from the confluence is 2.212 *km*, and from the source of the Naryn -3.019 *km*. The length of the river within Kazakhstan from the Shardara reservoir to the Aral Sea is 1.627 *km*, including 346 *km* in the South Kazakhstan province and 1,281 km in the Kyzylorda province (UNDP & EU, 2017).

The largest tributaries of the Syr Darya in Kazakhstan are the Keles, Arys, (Badam, Boroldai, Bugun flow into the Arys River and Shoshkokul Lakes), as well as small rivers flowing from the southwestern slopes of the Karatau Range.

The area of the Syrdarya River basin from its source to the Tyumen-Aryk railway station, where the watershed line can be traced, is 21,900 km^2. In the runoff formation zone (mountainous part of the basin), the main source of supply is warm water from seasonal snow cover, with a smaller proportion of water from glaciers and “eternal snows”, as well as rainwater.

The main volume of runoff, amounting to 70% is formed in the upper part of the basin, up to the outlet from the Fergana Valley. The runoff of right-bank tributaries upstream of the Shardara reservoir accounts for 21-23% of the total water resources flowing into Kazakhstan. The share of flow of the Arys River and other rivers flowing from the Karatau Range in Kazakhstan is 9-7%.

Figure 1. Scheme of location of water management basins of the Kazakhstan

Balkhash-Alakol basin: The Balkhash-Alakol basin occupies a vast territory in southeastern Kazakhstan and part of the adjacent territory of China. Its area is 413 x km^2, including 353 km^2 in the territory of Kazakhstan. The Kazakhstan part of the Balkhash-Alakol basin includes the territory of Almaty oblast, Moyinkum, Kordai and Shuysky districts of Zhambyl oblast, Aktogai, Shet and Karkarala districts of Karaganda oblast, Urjar, Ayagoz districts of East Kazakhstan oblast. The Chinese part of the basin includes the north-western part of Xinjiang Uygur Autonomous Region. The largest megalopolis of Kazakhstan, the city of Almaty, is also located in the territory of this basin.

The main volume of water (77%) in this basin is in lakes, mainly in Balkhash, and cannot be used in the main irrigated massifs of Almaty province. The share of river water is 14% while water from reservoirs is 5%.

Ertis basin: The Ertis River basin includes the Ertis River and its tributaries. The Ertis River is one of the major rivers of Kazakhstan. Its length, including the Black Irtysh, is 4.2 thousand km.

The average flow of the Yertis River at the entrance to Kazakhstan is about 300 cubic meters per second (9 cubic km/year); at the border with Russia, at Cherlak, it is 840 cubic meters per second (27 cubic km/year).

There are three large reservoirs along the Yertis River in Kazakhstan: Bukhtarma, Ust-Kamenogorsk and Shulbinsk reservoirs, which have a regulating influence on the river flow.

It is the most water-secured basin. The volume of reservoirs is 7.7 x 10^9 m^3 (18%) of the basin's water fund) and is the largest in Kazakhstan. Lakes contain about the same amount of water -16%.

Ural-Caspian Basin: The Ural-Caspian River Basin covers an area of 415,000 *km²* within the country and includes the catchment area of the Ural River (236,000 v), the Volga-Ural interfluve (107,000 *km²*) and the Ural-Emben interfluve (72,000 *km²*). In general, the Ural River Basin includes part of the territory of the Russian Federation, West Kazakhstan, Atyrau oblast and part of Aktobe oblast. The peculiarity of the basin is that almost half of the surface water flow is concentrated in the Kigach River, which is a branch of the Volki River delta and is located on the territory of Kazakhstan only in its estuary part, which significantly complicates the use of the flow of this river. Therefore, the main used water artery of the basin is the Ural River, the flow of which is 8.25 x 10^9 m^2.

Yesil basin: *The Yesil* River Basin occupies an area of 245,000 km^2 of the country. This is one of the basins least endowed with water resources. Most of the water reserves are concentrated in lakes -55% river runoff is 34% and 7% is accumulated in reservoirs. The main water artery is the Yesil River with several large tributaries flowing in the north from the Kokshetau Upland and in the south from the spurs of the Ulytau Mountains. The Yesil River originates from springs in the Niyaz Mountains of Karaganda Oblast (the northern fringe of the Kazakh Shallow Basin). Its length is 2,450 *km*, including 1,717 kilometers running through the territory of Kazakhstan within Akmola and North-Kazakhstan regions. The most significant tributaries in terms of water content and length are the Koluton, Zhabai, Tersakkan, Akan-Burluk and Iman-Burluk rivers.

The peculiarity of the basin's rivers is the uneven distribution of runoff, not only by seasons of the year, but also by years. Water discharges in different years can differ hundreds of times, which significantly complicates the economic use of resources of these rivers.

Nura-Sarysu Basin: The territory of the Nura-Sarysu Basin includes the basins of the Nura and Sarysu rivers, Tengiz and Karasor lakes. The Irtysh-Karaganda Canal (now the Satpayev Canal) was built to increase water resources in this basin, the share of which can reach 18% of the total balance under the design load. The share of groundwater is 25% the rest of water resources are represented by surface sources: 20% in lakes, 4% in reservoirs and 33% in river beds.

The largest river in the basin, the Nura River, originates from the western spurs of the Kyzyltas Mountains and flows into Lake Tengiz. The length of the river is 978 *km* and the catchment area is 58,100 km^2. The main tributaries of the Nura River are the Sherubainura, Ulkenkundyzdy and Akbastau rivers.

The Sarysu River begins with two branches of the Zhaksy Sarysu and after 761 *km*, after their confluence near the village of Atasu, it flows into Lake Telekol in the Kyzylorda region. The total catchment area of the Sarysu River is 81,600 km^2. The main tributaries are the rivers Karakengir and Kensaz.

The territory of the river basin belongs to the areas of sharply expressed insufficient moisture content. The peculiarity of the rivers of the basin is that the main volume of annual runoff (up to 90% and higher) takes place during the short period of spring floods. During the summer-autumn-winter low-water period, rivers discharges decrease significantly, and most rivers have no flow during this period.

There are about 2.000 lakes and more than 400 artificial reservoirs in the Nura-Sarysu river basin. Most of the lakes are located in the basins of the Nura and Karkaralinka rivers.

Shu-Talas Basin: The territory of the basin is formed by the Shu, Talas and Asa rivers, its total area is 64,300 km^2 (includes part of the territory of the Kyrgyz Republic).

The main part of the basin territory (73%) lies in the zone of deserts and semi-deserts, spurs of the Tien Shan Mountain systems occupy 14% of its territory. From the point of view of agricultural use, the foothill steppe part, which occupies 13% of the territory of Zhambyl region, is of the greatest interest.

In the Shu-Talas River basin, along with large rivers, there are 204 small rivers (140 rivers in the Shu River basin, 20 rivers in the Talas River basin and 64 rivers in the Asa River basin), as well as 35 lakes and 3 large reservoirs.

On the territory of the Kyrgyz Republic there is the Orto-Tokoy Reservoir on the Shu River with a design capacity of 0.42 x 10^9 m^3 and the Kirov Reservoir on the Talas River with a design capacity of 0.55 x 10^9 m^3 (on the Ters River there is the Ters-Ashybulak Reservoir with a capacity of 158 x 10^9 m^3 and the Tasotkel Reservoir on the Shu River with a design capacity of 620 x 10^9 m^3). Thus, the flow of the main rivers of the Shu, Talas and Asa basins is fully regulated. The basin's reservoirs are mainly for irrigation purposes.

Flow formation of the Shu and Talas rivers and the Kukureu-su River, the main tributary of the Asa River, occurs entirely within the Kyrgyz Republic.

Tobol-Turgai Basin: The total area of the river basin, consisting of the basins of the Tobol, Torgai and Irgiz rivers, is 214,000 km^2. The territory of the basin stretches from north to south for 600 km and in the direction from east to west for 300 *km* It is the poorest basin in terms of water resources. The share of groundwater is 15%, the rest of the water is represented by surface sources: 33% in lakes, 17% in reservoirs and 35% in rivers. The surface runoff of the basin's rivers is formed exclusively during the period of snow cover melting. The annual runoff of rivers in the Tobol-Torgai river basin in some years is subject to significant fluctuations, the peculiarity of which is the alternation of high-water and low-water years. In high-water years, river runoff exceeds average long-term values by 3-5 times, and in low-water years it decreases by 0.6 – 0.15 of average annual values.

The Tobol River begins in the Ural Mountains. It is a typically flat steppe river, with low water within Kazakhstan. More than 90% of the flow comes in spring. The left-bank tributaries of the Tobol - the Sytasty, Ayat, and Uy rivers - also begin on the slopes of the Ural Mountains. Only the Ubagan River flows in from the right. The natural regime of the Tobol River is changed by 8 reservoirs, two of which - Verkhnetobolskoye and Karatomarskoye - provide the regime of multi-year flow regulation. Within the basin, there are more than 5,000 lakes, 80% of which have a mirror area of less than 1 km^2 . Most of the lakes dry up in summer. The largest lakes are Kushmurun, Sarykopa, Aksuat and Sarymoyin.

The most significant waterways of the country are the Ertis, Yesil, Ili, Syr Darya, Ural, Tobol and other rivers, where most of the river flow is concentrated. Populated areas are located along these rivers, and industrial and agricultural production is developed.

The water resources of rivers determine the level of water availability in all sectors of the economy and water security of the country.

Total river water resources consist of local (formed on the territory of the country) and transboundary (from neighboring countries) water resources. The average annual parameters of water-resource potential of the country's rivers in the context of water management basins are presented in Table 1.

As of March 1, 2023, the average annual river flow in Kazakhstan has decreased by 12.5 km^3 compared to 1960, of these waters, local rivers account for 9 km^3 or 72% of the total reduction and transboundary rivers -3.5 x 10^9 m^3 or 28% (GoK, 2024). Reduction of local river flow occurred in all basins, except for the Balkhash-Alakol and Tobyl-Torgai basins.

The situation with surface water resources availability varies considerably in different regions of the country. The south-eastern and eastern regions of the country (the Ertis and Balkhash-Alakol water basins) are the most provided with their own surface water resources. Central Kazakhstan (the Nura-Sarysu water basin) is among the least provided with its own water resources.

The southern, south-eastern and western regions of the country (Aral-Syrdarya, Balkhash-Alakol, Shu-Talas and Zhaiyk-Caspian water basins) are the most dependent on water inflow from neighboring countries.

The ecological demand of natural-economic systems has a special status under water resources use, as it accounts for almost half of the generated runoff volume. Ecological requirements of natural-economic systems of the republic to water resources include nature protection and sanitary-epidemiological releases to lower reaches.

Table 1. Average annual river flow resources

No	Water management basins	Current assessment, 10^9 m^3			
		Total	Including		
			neighboring countries	Republic of Kazakhstan	
				total	of which outflow outside
1	Aral-Syrdarya	18.68	16.9	2.16	0.38
2	Balkhash-Alakol	29.04	13.5	16.5	0.96
3	Yertys	33.46	8.32	26.5	1.36
4	Yesil	2.68	-	2.68	-
5	Nura-Sarysu	1.57	0.7	0.87	-
6	Tobyl-Torgay	2.13	0.45	1.68	-
7	Zhaiyk-Caspian	11.0	8.86	3.13	0.99
8	Shu-Talas	3.71	2.77	0394	-
9	Bottom line:	102.3	51.5	54.46	3.69

Source: Institute of Geography and Water Security of the Republic of Kazakhstan

The problem of groundwater use is very acute in Kazakhstan. According to the data for 2023, there are 4,416 deposits (5,384 sites) with approved exploitable groundwater reserves of 43,120,560 m^3 in the territory of the country, including by categories (GoK,2024).

A - 13,428,230 $m^{3/}$day; B-13,481,260 $m^{3/}$day; C1 -10,675,310 $m^{3/}$day; C2 -5,535,750 $m^{3/}$day. The forecast reserves are about 40 km^3/year.

The groundwater exploration reserves are subdivided according to their intended use, for:

1) D*omestic and drinking water supply -13,882,660 m*$^{3/}$day (3,692 fields, 4,288 sites).

2) *Industrial and technical water supply*, drainage water (DW) -1,932,600 $m^{3/}$day (377 fields, 407 sites).

3) *Irrigation of lands -17,384,910 m*$^{3/}$day (155 fields, 287 plots).

4 *Domestic and industrial and technical water supply - 3,047,230 m*$^{3/}$day (164 fields, 314 sites).

5) *Household and drinking water supply together with land irrigation* - 4,951, 940 $m^{3/}$ day (18 fields, 78 sites).

6) *Household drinking water, industrial and technical water and for land irrigation* -725,000 $m^{3/}$day (1 field).

7) *Household and drinking water, land irrigation, reserves for Compensation of damage to spring runoff -1,109,700 m*$^{3/}$day (1 field, 3 sites).

Distribution of groundwater resources over the territory of Kazakhstan is extremely uneven. About 68% of the total groundwater resources with mineralization up to 1 g/l are concentrated in the southern region- Almaty, Zhambyl, Turkestan and Kyzylorda provinces. Aktobe region is reliably provided with groundwater reserves for household and drinking water supply.

West-Kazakhstan, Kostanay, Akmola regions belong to partially provided areas, and Atyrau, Mangistau, North-Kazakhstan regions belong to insufficiently provided areas.

During the period from 1960 to 2020, a hydrogeological survey was carried out throughout the territory of Kazakhstan with the development of maps at a scale of 1:200000. Currently it is needed to update available data and materials, conduct comprehensive large-scale hydrogeological surveys with i) specification of groundwater reserves, ii) areas of distribution of underground water layers, iii) their capacity and coordinates of deposits in the context of provinces and river basins. Up to 2023, prospecting and exploration works have been carried out for most villages across the country to define resources for drinking water supply.

1.2. Water intake

Water withdrawal for the needs of economic sectors and population in 2020 amounted to 24.6 x 10^9 m^3 in 2021 – 24.5 x 10^9 m^3 and in 2022 – 24.9 x 10^9 m^3 (GoK, 2024). The trend seems to be stable but should be expected to increase due to accelerated development in the oil and gas sector in Western Kazakhstan and the mining and industrial sector in Central Kazakhstan.

Water consumption by sector shows the dominance of agriculture and industrial water use (Figure 1)

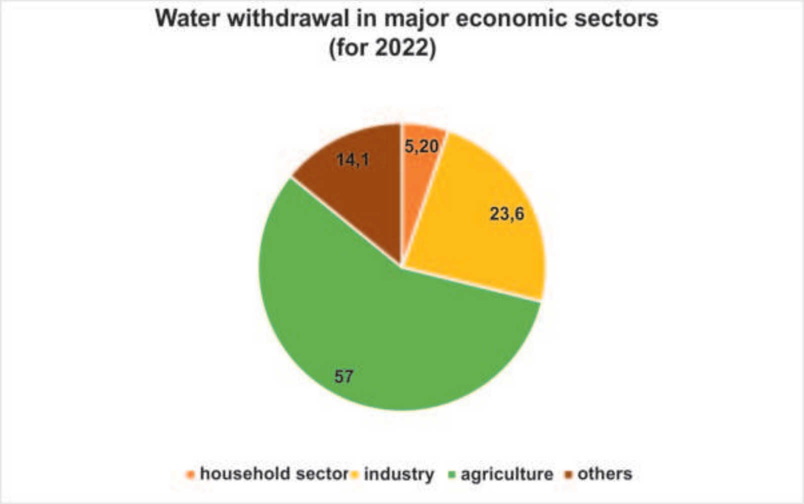


Figure 1. Water withdrawal by major economic sectors, %

Indicators of water withdrawals and losses in agriculture, industry and municipal and domestic sector are given in Table 2. Comparison of data in the table (Table 2) shows practically stable water withdrawal volume. Losses also remained at the same levels. On average from 2020 to 2022, 4.3% of the total water intake is used for municipal and domestic needs, of which 60.5% is taken from surface water sources and 39.5% from groundwater sources. There is a slight decrease in losses in the domestic sector from 15.8% in 2020 to 15.4% in 2022.

201 fields with reserves of 10,000 - 50,000 $m^{3/}$day (average 23,800 $m^{3/}$day) have been explored for household and drinking purposes. Of these, 50 fields with proven reserves of 50,000 - 10, 0000 $m^{3/}$day, 55 fields with proven reserves of 10,0000 - 500,000 $m^{3/}$day, 10 fields with proven reserves of 500,000 - 1, 000,000 $m^{3/}$day and 8 fields with proven reserves of more than 1,000,000 $m^{3/}$day.

Table 2. Water withdrawals and losses by the main sectors

Economic sectors	Years, intake and loss rates, 10^9 m^3							
	2010-2019		2020		2021		2022	
	intake	losses	intake	losses	intake	losses	intake	losses
Utilities	0.94	0.18	0.95	0.15	1.0	0.17	1.3	0.2
Agriculture	15.17	2.94	15.5	3.1	14.7	3.0	14.2	2.7
Industry	5.59	0.18	5.8	0.15	5.9	0.2	5.9	0.2
Others	3.16	0.34	2.35	0.3	2.9	0.3	3.5	0.3
Total	24.86	3.63	24.6	3.7	24.5	3.67	24.9	3.4

Domestic and drinking water supply of the regions, which are insufficiently

Provided with water resources is possible to be solved through construction of group water conduits (redistribution of groundwater resources). For example, at the expense of Kokzhide, Aishuak and North-Aishuak fields, which are located on the territory of Aktobe province, it is possible to cover a significant area of Atyrau and Mangistau provinces and solve water demand.

In West-Kazakhstan region, the solution to water supply issues it is possible to involve exploitation of Tokpai, Yanvartsev and Kushum groundwater deposits.

Industry accounts for 23.6% of the total water intake; of which 94% is met from surface sources, and 5.3% from groundwater sources. Of the total water withdrawal by industry, 75% of the normatively treated water is discharged into water bodies. The withdrawn amount of water has been utilized by 97% and the losses are increasing from 2.6% in 2020 to 3.4% in 2022. The increase in losses is also almost proportional to the increase in water withdrawal. The volume of recycled water supply is 9.3 x 10^9 m^3 and reuse is 1.1 x 10^9 m^3. At the same time, industrial enterprises, based on the existing production capacities, have reached the maximum possible values of recycled and repeated water supply. A further increase of volumes of recycled and repeated water supply is possible in case of development of existing or new enterprises due to industry production enlargement.

Dynamics of water withdrawal by water management basins of Kazakhstan for regular irrigation demonstrates that most water intake takes place in Aral-Syrdarya basin, where most agricultural lands of the country is accumulated (Table3).

The share of water consumption by agriculture is 60% of the total water withdrawal. On average, from 2020 to 2022, water withdrawal for agriculture is 14.8 x 10^9 m^3 , of which 77% was used for regular irrigation on an area of 1.18 10^6 ha. and the remaining 3.61 x 10^9 m^3 was distributed between firth irrigation, hayfield flooding, agricultural water supply and pasture watering. 98.8% of water was taken from surface sources.

Table 3. Dynamics of water withdrawal by water management basins of Kazakhstan for regular irrigation

Water/agricultural basins		Aral-Syrdarya	Balkhash-Alakol	Yertys	Yesils	Zhaiyk-Caspian	Nura-Sarysu	Tobol - Torgay	Shu-Talas	Bottom line:
2010-2019	Irrigated land, 10^3 ha	606	396	66	4	10	19	6	145	1 254
	Water intake, 10^6 m^3	7,154	3111	227	8	46	75	13	1 075	11 710
	Specific consumption m^3 /ha	11,8	7,8	3,4	1,9	4,4	3,9	2,3	7,4	9,3

2020	Irrigated land, 10^3 ha	642	456	49	6	12	24	6	84	1 277
	Water intake, 10^6 m^3	7 456	3 401	165	10	46	74	13	936	12 101
	Specific consumption m^3 /ha	11,6	7,5	3,4	1,8	3,9	3,1	2,2	11,2	9,5
2021	Irrigated land, 10^3 ha	536	453	48	9	12	9	7	104	1177
	Water intake, 10^6 m^3	6920	3310	158	14	48	74	13	936	12 101
	Specific consumption m^3 /ha	12,9	7,3	3,3	1,5	4,1	7,9	2,0	9,0	10,3
2022	Irrigated land, 10^3 ha	590	312	52	8	15	20	8	139	1 144
	Water intake, 10^6 m^3	6 781	3 347	174	5	47	74	20	1 040	11 489

Sources: Reports of Basin inspections on regulation of water resources use and protection of the Water Resources Committee of the Ministry of Water Resources and Irrigation of the Republic of Kazakhstan

Starting from 2020, for agriculture there was a decrease in the volume of water withdrawal for irrigation and irrigated lands under practically unchanged ratio of losses to water withdrawal. The largest agricultural user of water resources is regular irrigation. On average, from 2020 to 2022, losses during water transportation through main canals amounted to 20% of the withdrawn water. However, considering losses in inter-farm and on-farm canals in the fields, losses reach more than 50% So far, 3,573 km (30 %) of 11,900 km of emergency canals of the republican property have been repaired by the end of 2020, the main share of losses in water transportation to irrigated lands falls on canals of communal and private property.

Statistical data on water withdrawal volumes and level of unproductive losses show that the most inefficient water use is observed in regular irrigation.

Moreover, in regular irrigation there is a negative trend of increasing specific water consumption norms from 8.5 *m^3 /ha* in 2011 - 2022 to 10 m^3/ha. According to Kazakh Research Institute of Water Management, this is due to climate change, which affects the increase in the norms of water consumption of agricultural crops. Thus, on average, the number of irrigations during the growing season increased from five to six.

Immediate and urgent measures are needed to correct the situation. First, it is necessary to accelerate the introduction of advanced water-saving technologies - up to

150,000 *ha/year* and solve accumulation of melt water and losses during its transmission, because this is an internal reserve of the country. To do this, 20 new reservoirs shall be built and reconstruct at least 15 existing reservoirs, modernize and digitalize at least 3,500 km of canals. The task is to provide an additional 2 x 10^9 m^3 of water by 2027 (Tokayev, 2023).

In general, for the development of irrigated agriculture, it is planned to bring the total area of irrigated lands up to 2.5 x 10^6 ha. and they should be provided with irrigation water without increasing water withdrawals.

In connection with large volumes of modern irrigation systems purchase, the issue of establishing production of water-saving irrigation technologies (sprinklers and others) will be considered.

According to the Kazakh Research Institute of Water Management, there is a disproportionate load on water resources in the main river basins and a related water resource deficit.

The degree of water resources utilization (anthropogenic load) in the context of water management river basins is presented in Table 4.

Analysis of the level of anthropogenic pressure on rivers shows the following: Nura-Sarysus water basin is characterized by a critically high load on water resources. Available water resources, 88% of which are used for production needs, are fully involved in economic turnover, and in the future socio-economic development of Central Kazakhstan, will depend on the safe operation of the Kanysh Satpayev Canal, which feeds the basin with water from the Yertis River.

Table 4. Water resources use in the context of water management river basins

Water Management basins	Water resources, 10^9 m^3		Water withdrawal, 10^9 m^3	Pressure on water resources, utilization rate			
	local	Total, including transboun-dary		Local	Category	Total, including transboun-dary	Category
Aral-Syrdarya	2.16	18.7	10.7	495.4	V	57.2	IV
Balkhash-Alakol	16.5	29	4.1	24.8	III	14.1	II
Yertys	26.5	33.5	3.8	14.3	II	11.3	II
Yesils	2.7	2.7	0.4	14.8	II	14.8	II
Zhaiyk-Caspian	3.1	11	2.4	77.4	V	21.8	III
Nura-Sarysu**	0.9	1.6	1.4	155.6	V	87.5	V
Tobyl-Torgay	1.7	2.1	0.1	5.9	I	4.8	I
Shu-Talas	1.0	3.7	2.1	210	V	56.8	IV

Notes: * Values of river water resources indicators are taken for average water years; **Excluding water supplied through the Kanysh Satpayev canal; *** I - low load, II - moderate; III - high, IV - very high, V - critical.

In addition to the tense water situation in the basin, there is a problem with the quality of the main rivers in the basin. Thus, according to the classification of surface water quality, the Nura River belongs to the fourth class, and the Kara-Kengir River to the fifth class, which requires taking measures to reduce pollutants in them. The main pollutants in these rivers are magnesium, phosphorus, and ammonium.

In the Aral-Syrdarya and Shu-Talas water basins, there is a very high pressure on water resources. In addition, almost 90% of river flow resources in the Aral-Syrdarya basin comes from neighboring countries of Central Asia, and in the Shu-Talas basin, 75% of river flow is formed on the territory of the Kyrgyz Republic.

The available water resources do not cover the needs of the population and economic sectors, which is a critical factor for further social and economic development of Turkestan, Kyzylorda and Zhambyl provinces.

In the Aral-Syrdarya water basin, the share of water withdrawal for agriculture is 98%, as more than 35% of the country's irrigated areas (Turkestan and Kyzylorda provinces) are in this basin. The most water-intensive crops such as rice and cotton are grown in these areas. On average, when water is supplied for regular crop irrigation, losses amount to 1.7×10^9 m^3 of the total water withdrawal.

In addition to inefficient water use and transboundary dependence, the ecological condition of the Syrdarya River is disturbed. Such pollutants as oil products, phenols and nitrogen compounds come in large quantities with the transit flow of the Syrdarya River from neighboring countries. Also, the Syrdarya River continues to be polluted by pesticides used in agriculture throughout its entire length.

In the Shu-Talas water basin, 97% of the total water withdrawal is used for irrigation, where water losses during transportation averaged 0.6 km^3 of the total water withdrawal. The Shu River is prone to pollution by sulfates, nitrite nitrogen, total iron, copper, zinc and phenols.

In the Esil water basin there is a high load on local water resources, 96% of which is used for domestic needs. Water losses in water supply systems amount to 15-20%. This is explained by the fact that the systems of group water pipelines in Northern Kazakhstan were put into operation 50-60 years ago and are both physically and morally worn out. Water supply to the city of Astana is also an acute problem due to the intensive development of the capital city, as well as the constantly growing population. Until 2020, water consumption of the capital's residents amounted to 269,000 m^3 per day, in 2022 -311,000 m^3 per day. According to forecasts, due to the active construction of the city into residential areas, water consumption will reach 340,000 m^3 per day by 2026.

Currently the water supply of the city is carried out from the only source -– Astana water reservoir, built in 1969 and designed for 500 thousand people. Due to the growth of the city population (1.3 million inhabitants), it is necessary to take measures to create a reserve source of drinking water for the city of Astana.

The main pollutants in the Yesil River are phenols, suspended solids, and magnesium.

The Zhaiyk-Caspian water basin has moderate pressure on water resources, with the limiting factor being that 71% of the river flow comes from the Russian Federation. The main problems in the basin are the depletion (shallowing) and pollution of the Zhaiyk River due to the regulation of the river and the discharge of pollutants from the Russian Federation. Thus, some of the main pollutants of the Zhaiyk River are heavy metals (copper, zinc, lead, cobalt, nickel, chromium, iron). A significant contribution to the pollution of the Zhaiyk River in Kazakhstan is made by the Yelek River, which is one of the most polluted water sources, due to pollution by several heavy metals, including chromium, copper, fluorides, boron compounds. In addition, due to natural and climatic reasons, in recent years there has been a reduction in the flow of the Oyl, Zhem, Saryozen and Karaozen rivers, which negatively affects the environmental situation in Atyrau and West Kazakhstan regions and is a constraint to economic development.

In the Balkhash-Alakol and Ertis River water basins there is a moderate load, and in the Tobyl-Torgai River basin - a low load on water resources. Accordingly, these river water basins have sufficient water and resource potential for further socio-economic development under the condition of maintaining water inflow from adjacent territories.

In the Balkhash-Alakol water basin, 83% of water from the total water intake is used in agriculture, where losses amount to one billion (10^9 m^3) of the total water intake. At the same time, it is necessary to take measures to maintain the level of Lake Balkhash at the level of 342 m according to the Baltic system. In turn, Lake Balkhash is subject to significant anthropogenic impact by copper, zinc, nickel, manganese. The most polluted are Bertis Bay and Torangalyk Bay, which are exposed to anthropogenic pollution from the industrial association "Balkhashtsvetmet".

In the Yertis water basin the priority measure is to improve water quality in the Yertis River, which at this stage is a donor for water supply for industrial and drinking water needs of Central Kazakhstan. Due to functioning of Bukhtarma and Shulbinsk reservoirs in hydropower mode there are problems of flooding of the Yertis River floodplain during spring floods. Due to the availability of free water resources in the basin, it is advisable to additionally study ecological and economic aspects of the possibility of transferring free resources of the basin to water-deficient regions of the country.

The available resources of river runoff in the Tobyl-Torgai basin amount to 2.1 x 10^9 m^3 , of which 29 % of the runoff is formed on the territory of the Russian Federation. In the Tobyl-Torgai river basin, water losses in water supply systems amount to 20%, which requires measures to reduce them. Analysis of the water situation in river water basins shows that it is impossible to rely on the available free resources of river runoff due to the extremely uneven distribution of river water resources over the country's territory. This causes instability and unevenness of water supply to water management basins and economic sectors.

According to preliminary estimates, the forecast water balance for the period up to 2030 shows a reduction in internal river flow resources from 102.3 to 99.4 x 10^9 m^3 due to a reduction in inflow from neighboring countries from 51.5 to 46.5 x 10^9 m^3 (Table 5). The increase in local resources can be explained, it is due to increased rates of glacier melt. However, as the area of glaciers shrinks, this runoff will decrease.

In the future, the country is expected to experience significant growth in population, animal population, aquaculture and industrial production, which will lead to an increase in water withdrawal for these needs.

1.3. Municipal and industrial water supply and wastewater disposal

One of the most significant and large consumer of water resources in the country is growing industry sector. The needs of the sector are met by the fresh water intake and groundwater sources (GoK, 2016).

Depending on the type of activity of the enterprise, the nature of the preferential use of water may be different. The rate of water consumption is determined on the basis of calculation in relation to a specific production technology. High volumes of water consumption and discharges into natural water bodies may characterize the imperfection of technological processes and water management schemes in production.

In some cases, the amount of water consumed depends on its quality.

An important reserve for saving fresh water resources, especially in industry sector is recycling of water and repeated usage. When implemented, water intake can be reduced by a factor of 5 to 10, and the discharge of waste water will be reduced accordingly.

Table 5. Forecasting of the river flow resources considering climate and anthropogenic loads by 2030

Water management basins	Local resources		Tributary		Total*
	Total	including outside outflow (return)	Total	inc. formed in the neighboring countries	Total
Aral-Syrdarya	3.17	0.48	14.4	13.9	17.1
Balkhash-Alakol	16.6	0.99	12.5	11.5	28.1
Yertys	26.5	1.31	7.13	5.82	32.3
Yesil	2.47	-	-	-	2.47
Zhaiyk-Caspian	3.08	0.97	8.63	7.66	10.7
Nura-Sarysu	1.96	-	-	-	1.96
Tobyl-Torgay	1.88	-	0.59	0.59	2.47
Shu-Talas	1.01	-	3.21	3.21	4.22
Total	56.7	3.75	46.5	42.7	99.4

Source: Institute of Geography and Water Security, Water Resources of Kazakhstan: Assessment, Forecast, Management (Институт географии и водной безопасности, монография “Водные ресурсы Казахстана: оценка, прогноз, управление”).

* Total runoff consists of available water resources, which are annually renewable local natural resources and the actual inflow of river runoff from outside the country, transformed by anthropogenic impact.

Wastewater from enterprises is one of the most common sources of pollution of water bodies. In addition to industrial, mining and processing enterprises, water pollutants include urban development, irrigation fields, various kinds of lagoons, storage facilities for solid, liquid waste and petroleum products.

The category of discharged wastewater mainly includes domestic, industrial, quarry, mine and mixed waters. Type of waste water treatment are mechanical, natural-biological and artificial-biological.

According to statistics, water supply companies in Kazakhstan in 2021 supplied 2.4742 x 10^9 m^3 for consumption, which is more than 24% in comparison with the volume in 2018, including the volume of water consumed by the population increased by 5.2% and amounted to 609,200 m^3. The average daily water supply per one resident amounted to 87.8 liters/person.

The total length of water supply networks in the country is about 98,000 km and 17,000 km of sewerage networks by the beginning of 2023. According to the survey results conducted in 2022, the average depreciation of water supply networks amounted to 43% and 55% of sewerage networks. In general, based on the normative document requirements, which stipulates term of reliable operation of 25 years, about 51,000 km of networks require major repairs or their complete replacement, from which 41,900 km of water supply and 9,200 km of sewerage networks (Karimov, 2023).

Generally, the problem with water supply is typical for many countries of the world. By 2050, water consumption on the planet is forecasted to increase by 55%. Global water demand will grow significantly over the next two decades in all the three components, industry, domestic and agriculture. Industrial and domestic demand will grow faster than agricultural demand but demand for agriculture will remain the largest. The growth in non-agricultural demand will exceed the growth in agricultural demand (Boretti & Rosa, 2019).

According to the Concept of Housing and Communal Infrastructure Development for 2023-2029, in 432 rural settlements in Kazakhstan, at the expense of the national budget, projects will be financed to connect centralized water supply, as well as reconstruction of worn-out water supply networks. At the same time, projects for wastewater disposal will be considered as a priority in large rural settlements with high development potential (GoK, 2024).

1.4. Agricultural water supply and pasture watering

In Kazakhstan, consumers of agricultural water supply are rural population, livestock breeding, enterprises for primary processing of agricultural products, household plots of population for individual subsidiary farming.

At present, the main limiting factor, the development of livestock farming is the uneven and insufficient watering of natural pastures. The effectiveness of the pasture watering mainly depends on the state of irrigation systems and facilities. In this regard, all problematic issues in the development of pasture watering and agricultural water supply can be divided into three categories: systemic, technical and technological, as well as availability of the relevant qualified personnel. Norms and regimes of animal water consumption on pastures fluctuate by the seasons over the year, which is caused by the change of climatic factors during the year and the condition of grass stands. As studies have shown, in the arid zone they also depend on the density (number) of animal watering places and animal husbandry technologies. Consequently, in the seasonal pastures, the volume of water consumption and calculated water flow rate should be determined by the number of seasonal water users. In accordance with the normative requirements, depending on the category of water consumers and considering natural conditions of the zone, average water consumption norms on pastures are accepted. Smaller water consumption norms are applied for young animals, larger ones - for adult animals, and for lactating uteruses water consumption norms shall be increased by 25%. (Yespolov, 2016}.

It is planned to reconstruct more than 7,000 kilometers of irrigation networks serving to agricultural lands of the country, digitalization of water accounting in 212 canals and reconstruction of 16 hydraulic structures. It is expected that as a result, by 2025 the water losses in irrigation will be reduced by 4 x 10^9 m^3.

Water disposal from agricultural water users is mainly decentralized.

The total agricultural area of Kazakhstan is about 217 x 10^6 ha., of which arable land is 35 x 10^6 *ha* (10th place in the world and 2nd in terms of arable land per capita), fallow land is 13 x 10^9 m^3 *ha*.

Irrigated agriculture is the main water consumer. According to the land balance as of November 1, 2023, the country has 2.3 x 10^6 ha. of irrigated land, of which 1.9 x million ha. (82,3%) are agricultural land (GoK, 2023). Kazakhstan plans to increase the area of irrigated land to 3 x 10^6 ha. by 2030. Restoration works within 5 years will be continued to restore 600,000 ha. of irrigated land. Thus, the area of irrigated land will be brought to 2.2 million ha. Further, from 2025 to 2030, 800,000 ha. of new irrigated lands will be put into circulation.

Although, Kazakhstan is rich with the land resources, it is has not enough water resources and is one of the most water scarce countries in Eurasia: only 2.8% of the country territory is covered with water, while two thirds is represented by arid zones where access to water is very difficult. The country is already starting to experience water shortages and according to UN projections, by 2040 it could face a significant water deficit of 50% of the total demand. Approximately two-thirds of total water withdrawal is used in agriculture for irrigation, with 11-15% of the water used being lost during transportation, mainly due to outdated irrigation infrastructure and low capital investment in modernizing irrigation systems, which are critical for increasing farmers' productivity. Overall, water resources are available for irrigation of 4 x 10^6ha. of agricultural land. However, only about 1.8 million ha. are currently under irrigation. The continental climate and limited availability of water resources means that water availability and weather conditions are very often key factors that affect agricultural output.

Currently, and before the main type of land reclamation work in the republic was done, regular and liman irrigation is prominent. Water use in irrigated agriculture includes needs of regular and liman irrigation. Regular irrigation is sufficiently developed in the south of the country- these are South Kazakhstan, Almaty, Zhambyl and Kyzylorda provinces. Liman irrigation has also certain development in the country, especially in the northern provinces.

Surface runoff is the main source of irrigated agriculture in the basin. An important measure aimed at rational use of water resources and saving surface runoff is intensive involvement of groundwater for economic use. The volume of groundwater suitable for irrigation in the country is 8.41 x 10^9 *m^3/year*. Groundwater use can be considered reliable opportunity for increasing irrigated areas in the country.

In a number of countries, the system of irrigation on the basis of wastewater usage is sufficiently developed, at present in the Republic of Kazakhstan, this type of irrigation is given due attention. The total amount of municipal wastewater with biological treatment will be 1.72 x 10^9 *m^3/year*, whereby you can irrigate 250 – 300,000 ha. In the future, Kazakhstan through wastewater irrigation can provide 0.8 - 1.0 x 10^6ha. of land (Myrzahmetov et al., 2013). Thus, rehabilitation and reconstruction of existing regular irrigation systems are the most important direction of land reclamation in solving tasks on increasing productivity of agricultural lands, saving water resources, increasing labor productivity in irrigated agriculture and environmental protection of the land and water resources.

1.5. Other industries

The fishery fund of the country includes significant water area of the Caspian and Aral seas, Lake Balkhash, Alakol system of lakes, Bukhtarma, Kapshagai and Shardara reservoirs and other water bodies of international, country and local importance.

The total area of water bodies, excluding the Caspian Sea, is about 5 x 10^6 ha. Kazakhstan has a rich fishery water fund and favorable conditions for intensive development of fish production and fishery. Taking into account the projected population growth of the country and based on the scientifically recommended annual consumption norm -13.4 kg/person, to meet the population’s demand for fish and fish products, it is necessary to increase the volume of commercial fish cultivation and fish imports to 272,000 tons/year (GoK,2024). In order to develop commercial fish farming and restore the number of rare and endangered fish species, it is necessary to develop fish farms, specializing not only in the cultivation of commercial fish, but also in fish planting material.

In general, water consumption by fish farms is low (especially considering the currently available closed-cycle fish farming technologies) and under proper operation the farms should not experience water shortages.

Recreation: Both large and small water bodies are used for recreation purposes. The most attractive lakes are Balkash, Alakol, Shalkar, lakes of the Borovsky group and others, reservoirs - Bukhtarma, Kapshagay, Karatomar, Karagalinsk, Tasotkel and most of the smaller ones. The Caspian Sea, the coast of which has long magnificent sandy beaches, is a unique water body for recreation. Thousands of small lakes in the northern and central regions of the country are of certain interest for organizing active recreation - hunting and fishing.

Currently, water consumption in the recreational and tourist sphere for all recorded types of institutions is about 2 x 10^6 m^3/year (GoK,2016).

The volume of wastewater disposal is assumed to be 90% of water consumption. *Lake, river and delta ecosystems, wetlands*: there are number of aquatic, landscape-ecological, delta ecosystems and wetlands in the country, which represent a natural complex formed by living organisms and their habitat, and for the restoration and conservation of which certain measures are required to restore their natural hydrological regime.

The peculiarity of surface water usage in Kazakhstan is the need to spend almost half of the limited resources of river runoff to maintain the level and salinity of inland water bodies (Balkhash Lake, Aral and Caspian seas), as well as to water the natural systems of river floodplains and deltas.

Since practically half of the volume of renewable water resources of the country is formed outside its territory, the settlement of issues of joint use and protection of water resources of transboundary water bodies is extremely important for the Republic.

The General Scheme considers and carries out calculations for the following objects: floodplain of the Yertis River, floodplain of the Shidertin-Olenta zone, deltas of the Syr Darya, Ile, Zhaiyk, Nura rivers, systems of lakes Alakol, Sasykkol and Korgalzhyn group of lakes, wetlands of the Torgai River basin (GoK,2016).

CHAPTER 2. INSTITUTIONAL FRAMEWORK OF THE WATER SECTOR

2.1. Existing regulatory framework

National water legislation is based on the Constitution of the Republic of Kazakhstan and consists of the Water Code and other normative acts. These include 28 international treaties, 11 Codes, 37 Laws, 21 Decrees of the President of the Republic of Kazakhstan and 115 Government Decrees, in one way or another, affecting the management of water resources.

The Water Code of the Republic of Kazakhstan, adopted in 1993, fixed the basin principle of water resources management. In 2003, a new Water Code was adopted, where the basin principle of water resources management was adopted. In 2016, by a decree approved by the Government the general scheme for the integrated use and protection of water resources in the country, and all river basins was adopted. The Water Code aims to manage the following areas:

-*Water resource management*: including the allocation, distribution, and conservation of water resources to ensure sustainable development and environmental protection;

-*Water quality protection*: by setting standards for water quality, monitoring and testing water resources, and imposing penalties or fines for polluting or contaminating water bodies;

- *Water use rights and permits*: by establishing a legal framework for obtaining and using water rights, including permits for activities such as irrigation, aquaculture, and hydroelectric power generation;

- *Water infrastructure and delivery*: including the construction, safe operation, management and maintenance of water supply and distribution systems, such as dams, canals, pipelines, and treatment plants;

- *Water User Associations and stakeholder involvement*: by promoting community participation and cooperation among various water users, including farmers, industry, and households, to ensure equitable and sustainable water use.

The implementation of the Code requirements was and remains challenging due to several aspects, i)limited funding to satisfy the investments required in water infrastructure and management systems; ii)limited public awareness of the regulation and its provision, which has led to a lack of understanding and support for water management policies and strategies; iii) inadequate institutional capacities at both national and local level due to insufficient resources, expertise and authority to implement the Code; and iv) limited public participation.

Dam management and safety of water infrastructure is addressed partly in the Water Code but also across several other bi-laws, including Law on Technical Regulation, Law on Civil Protection. However, important gaps to strengthen the regulatory framework and establish a specialized authority to oversee the safe management of water infrastructure. There are six main goals of the Water Code of 2003: a) clarify and expand the competencies of governmental water management bodies; b) clarify and regulate water property issues; c) clarify the types of the allowable water use; d) prioritize environmental standards in water management; e) detail the issue of trans-boundary water use and regulation; and f) adopt the National IWRM Plan as the key WC enforcement mechanism (Genina,2007).

The Environmental Code of the Republic of Kazakhstan was adopted on 2 January 2021 to replace the 2007 Environmental Code. Following the recommendations by the OECD, Kazakhstan introduced considerable changes in the 2021 Code, when compared with the 2007 Code. Several new provisions were inspired by the European Union (EU) environmental legislation. The 2021 Environmental Code entered into force on 1 July, 2021. It regulates relations in the sphere of protection, rehabilitation and conservation of the environment, use and restoration of natural resources in the course of business and other activities connected with the use of natural resources and impact on the environment in the territory of the Republic of Kazakhstan. The code has a specific section dealing with the protection of water bodies, specifically dealing with:

1. *Establishment of water quality standards with regards to environmental*, drinking water, and fisheries. Also, through the establishment of maximum permissible concentrations of pollutants allowed in surface and groundwater bodies.

2. *Establishment of standards of permissible discharges and pollutants,* through the definition of maximum permissible mass and concentration of pollutants that can enter a water body.

3. *Environmental requirements for wastewater discharge*: defining the requirements needed to obtain an environmental permit to discharge of wastewater into natural surface and ground water bodies.

4. Environmental requirements for the development of activities in water protection zones and coastal areas.

5. *Monitoring to ensure compliance with permissible discharge standards*.

The Code on Mineral Resources and Subsurface Use was adopted in 2017 and has been recently amended in 2022. In the sphere of water resources, the law regulates relations connected with the use and protection of groundwater.

There are also several Sanitary Rules and Regulations which include several tens of documents governing quality of water for various purposes, water quality monitoring methods and other parameters (WB, 2024).

Because of transboundary water resources Kazakhstan has signed several transboundary agreements with neighbouring countries: Kyrgyzstan, Tajikistan, and Uzbekistan, but also with China and Russia. The level of implementation of transboundary agreements varies depending on the specific agreement and the country it was signed with.

The current legal framework, regulating the issues of transboundary water resources use and protection can be currently divided into the following blocks of documents: governing general provisions; regulating the issues of access to information, conducting EIA (environmental impact assessment); related to water quality; regulating issues of research, monitoring of transboundary water bodies; regulating general issues of water resources allocation and water management; regulating the allocation of water resources to transboundary basins (Turmagambetov et al., 2011).

In accordance with the water legislation, the Water Fund of the Republic of Kazakhstan includes the totality of all water bodies within the territory of the Republic of Kazakhstan included or subject to inclusion in the state water cadaster. The central goal of the Water Code is to achieve and maintain an environmentally safe and economically efficient level of water use and to protect water resources in order to preserve and improve the living conditions of citizens First, the strengths and innovations of the WC will be discussed and then its major limitations will be examined.

2.2. Water resources management – institutional framework

State management in the field of water fund use and protection, water supply and water disposal is carried out by the President of the Republic of Kazakhstan, the Government of the Republic of Kazakhstan, authorized body, department of the authorized body, authorized body in the field of public utilities, local representative and executive bodies of oblasts (cities of republican significance, capital) within their competence established by the Constitution, Water Code of the RK, other laws of the Republic of Kazakhstan, and acts of the President of the Republic of Kazakhstan.

State management in the field of water fund use and protection, water supply and water disposal are based on the principles:

- state regulation and control in the field of use and protection of the water fund, water supply and water disposal;

- sustainable water use - combination of careful, rational and integrated water use and protection;

-creation of optimal conditions for water use, preservation of ecological sustainability of the environment and sanitary-epidemiological safety of the population;

-basin management;

-separation of functions of state control and management in the field of water fund use, and protection and functions of economic use of water resources.

-the management levels in the field of water fund use and protection are inter-state, state, basin and territorial taking into account complexity and subordination (Table 6) (Nikolaenko et al., 2016).

Table 6. Institutional structure of water resources management in Kazakhstan

Level	Management and control body	Authority
Interstate	Interstate Coordination Water Commission (ICWC)	Development of strategic frameworks; regulation of transboundary water bodies; control of water withdrawal limits; development of regional programs and projects; coordination of joint scientific research
	ICWC Scientific-Information Center	
	Intergovernmental Commissions	
State	Government of the Republic of Kazakhstan	Formation of strategic policy; regulation of water relations at the national level; dam construction and operation; international cooperation.
	Water Resources Committee of the Ministry of Agriculture of the Republic of Kazakhstan	Development and implementation of sectoral programs and plans; coordination and methodological guidance; development of norms and rules for water use; approval of limits and tariffs; development and approval of rules for operation of water management facilities; implementation of state control in the field of water resources use and protection; determination of procedures for maintaining water cadastre and monitoring; approval of drinking water use regime; development and implementation of investment projects, regulation of dam construction and operation.

Continuation of Table 6

	Committee on construction, housing and Public Utilities and Land Resources Management of the Ministry of National Economy of the Republic of Kazakhstan	Development and approval of relevant regulatory and legal documents and methodological support in the field of public utilities in settlements; development and approval of rules for technical operation and use of water supply and wastewater disposal systems in settlements; development and approval of rules for calculating norms of consumption of public utilities; development of rules for subsidizing the cost of drinking water supply services.
	Committee for Environmental Regulation, Control and State Inspection in the Oil and Gas Sector of the Ministry of Energy of the Republic of Kazakhstan	Implementation of control and supervisory functions in the field of water resources quality assurance; development and approval of normative and legal acts in the field of environmental impact; conducting state environmental expertise; approval of limits and issuance of permits for emissions into the environment; issuance of complex environmental permits.
Basin	Basin authorities	Management of water resources of the hydrographic basin on the basis of the basin principle; coordination of activities of water relations subjects on water resources use; preparation and implementation of basin agreements, state control over the use and protection of the water fund; maintenance of state accounting, state water cadastre and state monitoring of water bodies by basins; issuance of permits for special water use.
	Pool Tips	The Basin Council considers topical issues in the field of water fund use and protection, water supply and sanitation, makes proposals and recommendations for the participants of the basin agreement.
Territorial	Oblast and rayon akimats	Management of water facilities; determination of water protection and sanitary zones and their economic use regime; participation in basin councils; ensuring implementation of measures on rational use of water resources in settlements and agricultural lands; development of payment rates for use of water resources from surface sources;subsidizing the cost of services for water delivery and discharge to agricultural producers and supply of drinking water to settlements; distribution of water use limits.

At the interstate level of water resources management, cooperation is achieved on issues of transboundary water resources sharing and protection. Therefore, considering the established international practice, the issues of water resources management, reduction or prevention of negative impacts, prevention of water losses in upstream and downstream sections of basins, and cooperation in the field of water quality protection should be prioritized in the agenda of discussions between the transboundary countries.

Water management projects of national or regional importance are implemented at the state (national) and basin management levels. Examples of water management measures at this level are construction of dams, reservoirs, centralized groundwater intakes, pumping stations, regulation of river flow and operation modes of large reservoirs, identification of alternative freshwater sources, and maximum reduction of losses during water supply and distribution.

Management plans at these levels should be based mainly on actual needs and consider existing social and economic conditions in the river basin. Lower level management plans should be consistent with general management plans, and general water policy should be oriented towards all management levels. An optimal compromise (in technical, economic and social relations) between the distance of water transportation to consumers and the proximity of consumers to water sources is necessary.

The territorial level of management is responsible for operation and maintenance of all water networks and facilities owned by the state. Work at this level is usually aimed at reducing water losses during transportation and distribution, at ensuring that water of appropriate quality and quantity is delivered to different locations at the required time, and at establishing direct and effective links between central and local organizations responsible for water resources in different districts.

Work is organized to improve the efficiency of water use by appropriate methods and means, to establish cooperatives and associations of water users, to interact between water users and territorial bodies responsible for water distribution, which ensures equitable water distribution and minimum water losses.

At this level, cooperation and control over water facilities owned by cooperatives and associations of water users or individuals is also carried out to ensure the safety and efficiency of these facilities. An important goal is pursued to create an effective non-state service network as well as specialized private companies for operation and repair of water management facilities and structures.

Under the basin management principle, the operation of most hydraulic structures, including river flow regulation and territorial redistribution of water resources, is determined by the general rules of water resources use in each basin, irrespective of the location of specific water management facilities, water consumers and water users. First, it refers to reservoirs, intra- and inter-basin transfers of river flow, by means of which its regulation in the river basin is carried out. Each reservoir and hydro-scheme in the basin, designed for flow regulation, operate in accordance with dispatch schedules calculated on the basis of solving the tasks of the whole basin.

The Water Resources Committee manages water resources use within water basins in the interests of all sectors of the economy, considering environmental rules.

Basin Water Authorities (BWAs), established in each main river basin, regulate the use of water resources and their protection within a particular river basin. BWOs are maintained only at the expense of budgetary funds.

Maintenance of hydraulic structures and water management facilities is carried out at the expense of receiving funds from water users for services on water supply to them. The objects of interstate and inter-oblast purpose, which are in the state republican ownership, are partially financed from the country budget.

At the basin level of management, it is crucial to consider the interests of the public, involve the population in the implementation of affordable projects and programs to improve sanitation, preserve natural watercourses and reservoirs, and create sustainable water supply systems.

Due to the lack of budgetary funds for water management purposes, significant deterioration of water management facilities and structures, there is a need to involve the non-state (private) sector in water management activities, mainly in terms of providing services for water delivery, repair and maintenance of water management systems. In the formation of such a market in the water sector, an important role will be played by basin water management bodies, which should set clear goals of denationalization in the water sector of the economy, determine its maximum permissibility, and the need for legislative support.

One of the important functions of water resources management is the organization of a clearly functioning system of issuing permits for special water use and licensing of water management activities, which are also entrusted to basin management bodies.

Rational use of water resources should be ensured by establishing cooperatives and associations of water users in various sectors of the economy, first in irrigated agriculture. Such cooperatives and associations are established at the initiative of water users on relatively small farms by area. But, as practice shows, for efficient operation of irrigation main canals and rational distribution of irrigation water, a cooperative or association should include farms of the whole irrigated area, the area of which can reach 10,000 –15,000 ha. and more. Establishment of effective operating cooperatives (associations) of water users will allow using irrigation water more economically, maintaining farm hydraulic structures and timely repairing them.

Further expansion of the private sector participation in the water sector in its various forms (management contract, lease, concession, and fully private company) based on prepared programs for the development of water management activities in the basin and territories included in this basin, implementation of water saving projects will require strengthening the coordinating and controlling role of basin water management bodies.

2.3 Functioning of main agencies involved in water management

The Ministry of Water Resources and Irrigation of the Republic of Kazakhstan is a state body of the Republic of Kazakhstan, which provides leadership in the formation and implementation of state policy, coordination of management processes in the areas of control over the use and protection of the water fund, water supply, drainage and irrigation.

The Water Management Committee is a state body and agency within the competence of the Ministry of Water Resources and Irrigation, which carries out regulatory, implementation and control functions in the field of water fund use and protection assigned to it by the Constitution, laws, other normative legal acts of the Republic of Kazakhstan.

The functions of the Committee include:

1) participation in development of rules for operation of water management facilities located directly on water bodies.

2) participation in development of rules for operation of water management, hydraulic systems and structures.

3) organization of design, survey, research and development and design works in the field of use and protection of water fund, water supply and water disposal outside settlements.

4) preparation and implementation of investment projects in the water sector.

5) participation in determining the procedure for leasing and trust management of water management facilities.

6) consideration of appeals of individuals and legal entities.

7) implementation of the organization of public procurement.

8) exercise other powers provided for by legislative acts, acts of the President of the Republic of Kazakhstan and the Government of the Republic of Kazakhstan (WMC, 2024).

State bodies may involve citizens and public associations for development of programs and implementation of measures on rational use and protection of the water fund. The priority direction of public management improvement is the realization of the mechanisms stipulated by the Water Code:

-development of schemes for integrated use and protection of water bodies;

-development of norms of permissible impact on water bodies, taking into account regional peculiarities and individual characteristics of water bodies;

-development of the procedure for water supply services under regular irrigation;

-development of new and updating of existing rules for reservoir use.

Improvement of public management is one of the fundamental factors contributing to the development of concerted actions oriented to the implementation of integrated water resources management principles in the Republic of Kazakhstan.

CHAPTER 3. CLIMATE CHANGE AND WATER RESOURCE MANAGEMENT

According to the RSE “Kazhydromet”, in Kazakhstan, increase in surface air temperature is expected to further increase by 0.8 - 1.2 ^{0}C, as well as changes in the average annual precipitation by 1-3% by 2030. A steady increase in the average annual air temperature is observed in all regions of Kazakhstan. On average, the average annual air temperature increase in Kazakhstan is 0.33 ^{0}C every 10 years (Kazgidromet, 2023).

Changes in basin hydrological cycles in Kazakhstan as a reaction to global and regional climate warming, which will lead to increased evaporation of moisture in river catchments with decreased water inflow to rivers, falling levels of the Aral and Caspian Seas, Lake Balkhash, increased economic demand for water resources, including increased irrigation rates for agricultural crops.

There is a rapid reduction in glaciers, which provide up to 50% of river runoff during the growing season. This factor also increases the danger of avalanches and mudflows, which requires additional study of dam construction in the foothill zones.

The continuation of these trends in the future will inevitably entail a sharp aggravation of water security problems and poses a real threat to the sustainable development of the countries of the entire Central Asian region.

In addition to the threat of water resources reduction, there is a tendency of inter- and intra-annual variation of river runoff, namely, an increase in water inflow in winter and a decrease in spring and summer. This creates additional limitations of water use for economic sectors, especially for agriculture.

Taking into account possible deterioration of climatic conditions, it is necessary to take appropriate measures for adaptation to new climatic conditions. This will require reduction of anthropogenic load on water bodies and application of water conservation measures at all levels of water use. Special emphasis should be placed on water use in agriculture.

Given that most of the territory of Kazakhstan is occupied by desert and semi-desert territory, many sectors of the economy, especially agriculture and water management, are highly sensitive to the observed deviations of climate transformation. In general, climate change has a significant impact on water resources in Kazakhstan, making the climate in agricultural regions drier. At the same time, the efficiency of water use in Kazakhstan is very low due to outdated irrigation technologies and poor water use practices. Some water management basins are already suffering from severe water shortages, and much of the irrigated land has deficit of water resources for agriculture. It is expected that the problem of water scarcity will worsen significantly over the next two decades due to inefficient use of water resources and can practically destroy agriculture.

The State Program on Water Resources Management of the Republic of Kazakhstan for 2014 - 2040 (GoK, 2014) was adopted to address the expected freshwater deficit. It sets the goal of ensuring water security of the Republic of Kazakhstan (Askarova et al., 2021).

According to experts, the causes of water resources deficit in the country are natural conditions, 90% of river flow occurs in the spring period and formation of about half of the flow on the territory of neighboring countries, as well as their extensive use, excessive irretrievable water consumption for irrigation and water losses. Thus, irrigation water productivity in Kazakhstan is 6 - 8 times lower compared to foreign countries (UNDP, 2021).

More than 44% of river flow in Kazakhstan is formed on the territory of other states, so the deficit will occur primarily due to intensive water use in neighboring countries, but Kazakhstan is unfortunately not lagging other countries in terms of irrational water use. Climate change intensifies the effect and leads to reduction of river water availability. The average annual air temperature is increasing, as in winter period, the number and duration of thaws increases, the depth of ground freezing decreases, due to which melt water goes into the soil and does not fill the rivers. And warm spring leads to the fact that water evaporates and, instead of accumulating in the reservoirs, enters the atmosphere. As a result, the regimes of the rivers change. Already today we observe shallowing of such rivers as the Ural (Zhaiyk), Tobol, Ili, Ertis, Yesil.

The water level in the Ural has fallen three times in the last 15 years. The reason for the shallowing of the Urals is not only climate change, but also the fact that the Reservoir Iriklinskoye accumulates water from the upper reaches of the Urals and does not release it to the lower reaches. Today in the river basin, in addition to the Iriklinskoye, there are 12 large reservoirs, each with a volume of at least 10 x $10^6 m^3$ of water. Since the Ural is a transboundary river, cooperation between Kazakhstan and Russia is necessary to solve the problem.

In turn, the drainless Lake Balkhash, which is 80% dependent on the glacier-fed transboundary Ili River, is most vulnerable to flow and climate change. The area and volume of the lake are highly variable in response to long-term fluctuations and short-term fluctuations in water levels. The flow of the Ili River from northwest China has been steadily declining since the 1970s, and the area of land used for agriculture and harvesting along the Ili River in China has increased by 30% over the past 20 years. Intensive water use is also occurring in Kazakhstan. More than 90% of the water withdrawal volume from the Ili River is used for irrigated agriculture, Kapchagai HPP, municipal and industrial water supply. Since 1970, 39 x $10^9 m^3$ of the river has been used to fill the reservoir in Kapchagai, which resulted in 2/3reduction of flow and lowering of the lake level. The fact that the Balkhash Mining and Metallurgical Combine annually discharges about 600,000 tons of industrial waste, including lead, zinc and copper, is an additional blow. Thus, with increasing demand for water resources in the transboundary Ili-Balkhash basin, increased evaporation due to the arid climate, rapid glacial melt and pollution, the unique ecosystem of Lake Balkhash is critically threatened.

3.1. Irrigation infrastructure and cropping pattern

Climatic conditions determine the peculiarities of agriculture in Kazakhstan. In the northern and central regions non-fallow farming is developed, in the south- irrigated farming. However, weather conditions are not always favorable for economic activity due to such dangerous phenomena as drought, dry winds, frosts, dust storms and ice. The recurrence of droughts increases from north to south (Askarova, 2021).

Kazakhstan has enormous agricultural potential that can help make economic growth more diversified and inclusive. One of the main advantages of the country's agriculture is its vast territory with a low population density, where large agricultural lands are available. The total agricultural area of Kazakhstan is about 217 x 10^6 ha, of which arable land is 35 x 10^6ha. (tenth in the world and seconded in arable land per capita), and fallow land is 13 x 10^6 ha. Due to the uneven distribution of agricultural land, agriculture varies significantly across regions. Crop production is mainly concentrated in the north -Akmola, Kostanay, North Kazakhstan regions, east -Pavlodar region and south -Turkestan region of the country, while extensive livestock farming is developed in the center, and mixed agriculture is developed in the southeast -Almaty, East Kazakhstan regions (Kurmanbekov et al.,2023).

The irrigation infrastructure in Kazakhstan is insufficiently developed, both in terms of coverage and condition. FAO (2020) reports that only 4.3% of the cultivated area (approximately 2.48 x 10^6 ha) is equipped for irrigation. Crucial crops such as cotton, rice, sugar beet, and fodder rely on irrigation. However, widespread degradation of irrigation and drainage (I&D) systems; caused by insufficient maintenance, limits agricultural productivity, especially in the southern region where agriculture has high profitability potential. High water consumption in agricultural irrigation is due to the lack of standardization and regulation of water supply, non-compliance with irrigation schedules, and suboptimal irrigation rates. Only approximately 3% of the total irrigated area, or over 95,000 ha., uses efficient irrigation practices, and the remaining are still using flood irrigation. Irrigation systems are yet very inefficient, with water losses in the transportation equivalent to 35 - 40%, although these losses do not consider those occurring on farm (Yessymkhanova et al.,2021). Therefore, upgrading the irrigation infrastructure is necessary to increase water use efficiency (WB, 2024). This task shall be implemented urgently due to the water scarcity, because of the ongoing climate change, enabling to eliminate unproductive water losses, better irrigation water distribution and finally to implement environmentally friendly farming system in the country. An important measure aimed at rational use of water resources and saving surface runoff is intensive involvement of groundwater in economic use. The use of groundwater makes possible for increasing area of the modern irrigation methods in the country.

3.2 Water Supply, wastewater consumers and infrastructure

The water supply networks in the country are installed over the time by the development of the settlements and other industries. According to estimations about 64% water supply networks require rehabilitation or complete replacement, 36% are in working condition. Most water networks were developed 25 - 40 years ago, and are already beyond their design lifetime. The total length of the sanitation networks in cities is over 12,000 km, which is half of the size of the drinking water supply network, evidencing the disparity in terms of network development between sewage and water supply (WB, 2024).

Currently, Kazakhstan has sewage treatment plants installed in 62 out of 89 urban settlements. The deterioration of sewage networks in the country averaged 52.2%.

In certain cities, this indicator is much higher, the sewage facilities in the East-Kazakhstan region, Karaganda and Pavlodar regions have the greatest wear and tear today. In the cities of Kokshetau, Shalkar, Kapshagai, Semey, Ridder, Karatau, Saran, Arkalyk, Ekibastuz, the deterioration is more than 90% (Association of Practicing Ecologists, 2023).

To solve the problem of wear and tear of sewerage systems and treatment facilities, the country since 2022 is developing a project of construction and reconstruction of sewage treatment plants in 53 cities of the country. The work will be carried out at the expense of loan funds of ADB and EBRD, under the execution of the Ministry of Industry and Infrastructure Development of the Republic of Kazakhstan.

The construction of sanitation facilities in rural areas needs to be given due attention, the priority is still water supply in urban areas. Therefore, the level of coverage of residential buildings in rural settlements by sewerage systems lags far behind the level of water supply coverage.

The development of water supply to the cities of Kazakhstan leads to serious pressure on the hydrosphere of the region, for example, water supply to the capital, which is growing intensively, may be limited, as there is a water deficit of up to $75 \times 10^6\ m^3$/year already by 2030.

According to UNDP experts, it is necessary to strengthen basin management, including the work of small basin councils, development of necessary conditions for implementation of their decisions and provisions of basin agreements. Integrated water resources management, transition to assessments of social, economic and environmental value of water resources in the production of goods and services will make it possible to increase the efficiency of rational environmental management. The basin councils should consider the increasing pressure of the changing climate on water resources on making their arrangements and decisions.

It is necessary to implement measures to reduce water consumption of large water consumers by using modern technologies, i.e. reducing freshwater consumption in industry, agriculture and public utilities. It is also necessary to properly plan the use of water resources by properly regulating river flows and rational territorial distribution of water resources. In addition, introduction of the new water-saving technologies, automatized systems of production process management, establishment of state and primary water accounting, legal and economic mechanisms for sharing water resources of transboundary watercourses are vital for the country water management for the upcoming years.

One of the main priorities shall be the introduction of new technological processes of production, transition to closed (drainless) cycles of water supply, where treated wastewater is not discharged, but repeatedly used in technological processes. Closed cycles of industrial water supply will make it possible to completely eliminate wastewater discharged into surface water bodies and use fresh water to replenish irretrievable losses.

To date, such a problem as wastewater treatment in the country has obtained special importance. In the composition of domestic wastewater, distinguish fecal wastewater, polluted mainly by physiological excretions of people, and economic wastewater, polluted by various household wastes, and detergents. A distinctive feature of domestic wastewater is the relative constancy of its composition and high degree of pollution. Organic substances of plant and animal origin make up the bulk of pollution. Domestic wastewater always contains many microorganisms that are products of human activity, among which may be pathogenic. This is the most epidemiologically dangerous part of pollution. For treatment of domestic wastewater, as a rule, mechanical, biological and chemical methods are used. Pollutants of domestic wastewater affect the choice of technological scheme of water treatment and the ecological situation in the area (Association of Practicing Ecologists, 2023).

The possibility of reuse of domestic wastewater in Kazakhstan exists and is already applied in some regions. For example, in Almaty there is a system of wastewater treatment and its use for irrigation of green areas and irrigation of public territories. Also, in the city of Astana, a system for processing wastewater used for fertilizer production has been launched. At present, scientists in Kyzylorda province are implementing a project "Development of safe wastewater utilization technology for irrigation of fodder crops and tree plantations under water deficit conditions in Kyzylorda province", the purpose of which is to reuse treated wastewater for production of fodder crops in pilot irrigation plots in Kyzylorda province with preservation of favorable ameliorative conditions.

However, now, wastewater reuse is not yet widespread in Kazakhstan due to the need to introduce special technologies and infrastructure. Nevertheless, due to the lack of fresh water in the region, the issue of wastewater reuse is becoming more and more relevant and will probably be actively developed in the future.

3.3. Water depletion trends and water demand forecasting

One of the critical problems in the field of water management in the region and country is the depletion of water resources associated with the reduction of inflow to transboundary river basins and the reduction of its own water resources, which in turn leads to the deterioration of drinking water quality.

Even though there are about 39,000 rivers and temporary watercourses on the territory of the country, the situation with resource endowment of surface water sources varies significantly. The annual river flow of all rivers of Kazakhstan is estimated at 100 km^3/year, about half of the flow is formed on the territory of neighboring countries, which in turn plays a primary role in water distribution in the regions. One of the deficient both in surface and groundwater is the Esil water basin with a total area of 245,000 km^2. The main water artery is the Esil (Ishim) River with a number of large tributaries flowing in the north from the Kokshetau Upland and in the south from the spurs of the Ulytau Mountains.

It should be noted that on the territory of North-Kazakhstan oblast about 2/3 of total water intake from surface water sources (2,426 water bodies), including the Esil River, is used for water supply to the population. About 1/3 of consumed water in the region is used for household needs, the rest volume - for agricultural and industrial needs. For each inhabitant of the region on average water consumption is about 55 liters per day, while in the country this figure is 140 -160 liters per day, including for urban residents this figure is about 200, for rural residents – 70 -75, i.e. rural population of Kazakhstan consumes three times less water than urban population.

The following main causes of water resources depletion and pollution in the North-Kazakhstan region can be identified: i) plowing of catchments near the shorelines of water bodies. ii) use of watersheds for pastures. iii) transformation of dried lake basins, shorelines into unauthorized - spontaneous dumps of household waste. v) overloading of water bodies with organic waste products. vi) lack of effective measures to prevent pollution, clean water bodies, shorelines and catchment areas.

One of the ways to solve these problems is to organize rational use of water resources, which in turn is possible only under sufficiently stable water balance of water bodies and satisfactory water quality. Drinking and fishery bodies play a special role in organization of the rational use of water resources.

Also, an important factor for the preservation of water bodies is the establishment of water protection zones and strips that help prevent their pollution, littering and depletion.

Thus, the water resources of the river runoff in the country due to anthropogenic activity decreased by 16.0 km^3 ·y–1. This is corresponding to the long-term forecast of climate change. Taking into account the expected decrease of transboundary runoff by 2030, there will be a further decrease in the country's water resources to 87.1 x 10^6 m^3/year and in low water years – less than.

50 x $10^9 m^3$ year. This indicates the threat of severe water shortages at the turn of 2030 –2050, which overall affects the national security issues. Reducing the pressure on the water resources and increasing freshwater resources are the ways to eliminate the water deficiency in Kazakhstan. In order to eliminate the water shortages, it is necessary the main water consumers use of modern technologies to reduce the consumption of freshwater in industry, agriculture, and municipal water consumption. Another possibility in water use optimization includes using ground freshwater resources, desalination of saline and brackish waters, and territorial redistribution of water resources. As Kazakhstan is in the lower reaches of large transboundary rivers, water availability largely depends on the economic "position" of neighbouring countries, the development of their economies, and population growth. Consequently, the issues of regulating the use and protection of water resources are of strategic importance, as well as adequate state policy formation. For the rational use and protection of water resources within the country, it is necessary to adopt a national plan for their integrated management and, on its basis, carry out complete rehabilitation and improvement of the existing water infrastructure. In addition, new water-saving technologies, automated control systems for production processes, state and primary water accounting need to be established and introduced everywhere. Improvement of interstate water relations is the second direction of state policy in this area. First, this means the establishment of legal and economic mechanisms for the joint use of water resources of transboundary flows (Tursuniva et al., 2022).

CHAPTER 4. WATER TARIFFS AND INVESTMENTS

4.1. Public investments into the water sector and future plans

The water management complex of Kazakhstan was formed during the Soviet ruled period to implement state plans for agriculture and water supply of settlements and industry. Other activities included protection of the territory from mudflows and floods, redistribution of water resources for the needs of the national economy. Therefore, investments in the water sector were arranged complexly depending on the projects' purpose. After the country has gained independence, management of the water sector and development of the water management complex are carried out by a gradual transition to market relations and commercialization of water sector services including water supply, irrigation, industrial consumption and others, which reflected in the developing water sector regulatory framework. However, up to date the main investment burden is met by the state. Funds to the water sector include both the state budget, and loans, grants and other technical support projects implemented with the involvement and support of the international financial organizations.

Currently, the country water management complex includes 331 reservoirs with a design capacity of 87.8 x 10^9 m^3, 125 hydroelectric complexes, 3,392 canals, 473 dams and 1,667 other water facilities. Most of the reservoirs have been operated without major repairs and reconstruction for more than 30 - 50 years and are high-risk facilities. The actual depreciation of water use facilities is estimated at more than 60%. The most difficult situation can be observed at certain structures in municipal and private ownership. The volume of investments from 2015 to 2019 increased by 2.4 times, which indicates a positive trend in investment in this industry (Koldasova. & Aydarova, 2021).

In general, the water sector projects need to be attractive from an investment point of view. The projects are implemented mainly at the expense of the public budget, therefore the sector needs to attract private investment (GoK,2024).

The Government of Kazakhstan has identified 16 projects in the water sector, in which it is necessary to invest more than 500 billion KZT. It is planned to attract preferential financing from the Islamic Development Bank (Tonkonog, 2024).

Within a Comprehensive Plan for the development of the water sector for 2024 -2030 framework, it is planned to build 20 new reservoirs with the volume of 2.4 x 10^9 m^3 on the territory of nine provinces. It is expected that the implementation of the plan will increase available water resources by 3.7 km^3, and the area of irrigated land - up to 2.2 million hectares, reduce annual irrigation water losses by 3 km^3, and provide water supply to 41 settlements with a population of more than 55 thousand people.

The implementation of a comprehensive plan to restore the country's entire water management infrastructure system will require, according to the estimations 2 trillion KZT (Kabzhalalova,2024). Therefore, financing shall be arranged not by budget money, but by attracting private investment. The government should redirect some of the ineffective state subsidies to agricultural producers to the development of irrigation infrastructure. Considering the environmental and social aspects of modernizing the water supply, it is necessary to attract investment from international development institutions.

4.2. Public-private partnership initiatives

As part of the implementation of the Kazakhstan - 2050 Strategy and the 100 Concrete Steps Plan of the Nation, the PPP Law was adopted on October 31, 2015, which created a new legal framework enabling to attract private investments into the country's economy, including the water sector. The PPP Law opened the possibility of PPP implementation in all areas of the economy, expanded contractual forms of PPP, established the possibility of participation in PPP projects of quasi-public sector entities, organizations providing project financing, as well as the possibility of entering into PPP agreements not only on the basis of a tender, but also through direct negotiations (introduction of private partner's property into circulation).

The UN Economic Commission for Europe, which unites the world's common experience of public-private partnerships, has developed recommendations for orienting PPPs for the benefit of society - the principles of "people first PPP", which presuppose the consideration of certain aspects, including zero tolerance to corruption and the right of the population to redress and to have their opinion considered. Considering these recommendations, in 2019 some orders of the Ministry of National Economy of the RK were developed and amended (Mataev, 2020).

In December 27, 2023 Metito, a global provider of intelligent water management solutions, has signed agreements with Kazakhstan Investment Development Fund (KIDF), Kazakhstan Centre for Modernization and Development of Housing and Communal Services JSC, and Akimat of Akmola region for the implementation of a transformative wastewater treatment project in the city of Kokshetau. This is considered historic agreement to pioneer Public-Private Partnerships in the water sector in Kazakhstan (Metito,2023).

Construction of a seawater desalination plant with a capacity of 50,000 m^3/day has begun in the Tokymak area of the Karakiyansky district of the Mangistau region.

The desalination plant is designed to provide drinking water to residents of the city of Zhanaozen. The Contract for the construction of the plant was signed with a consortium led by the international company Metito LLC together with Akzhol Kurylys LLP, Caspian HES Consulting LLP, and SMK-Atameken LLP in August 2023, and construction work is planned to be completed by the end of 2024. The plant scheduled to reach its design capacity in the spring of 2025 (Watermagazin.ru, 2023).

In upcoming years, PPP projects are planned to be enlarged in water sector of Kazakhstan, to implement the government policy on the water security of the country.

4.3. Water tariffs and public policy

The Tariff Formation Rules have been amended and supplemented for the last time on February 11, 2024 by the Order of the Ministry of National Economy (Ministry of National Economy (2024). According to the new rules, the municipal water tariffs have been appointed by a differentiated approach depending on the consumed volume of water in the month. For this reason, consumers are divided into four groups, depending on the volume of water consumption.

Group I: those consuming water up to 3 m^3 /month (49% of the population) will pay the existing current tariff.

Group II: those consuming 3 - 5 m^3/month (20%) will pay 20% more than the current tariff.

Group III: those consuming 5 -10 m^3/month (20%) will pay 50% more than the current tariff.

Group IV: those consuming more than 10 m^3/month (11%) will pay 100% more than the current tariff.

Currently the average tariff for water supply services in Kazakhstan is 137.29 KZT/ m^3 (excluding VAT), for population – 82.66 KZT/ m^3 (excluding VAT). Drinking water tariffs differentiated depending on the region. For example in Astana area the water supply tariffs is different for the population (0,19 USD/m^3) and other residential consumers (0.49 - 0.68 USD/ m^3.), (Astana Su Arnasy, 2024).

The country approved a five-year period tariff for regulated services on water supply through canals, came into force from January 1, 2024 for a five-year period (Kazvodkhoz, 2023). Tariffs for regulated service on water supply through canals are differentiated by consumer groups depending on the method of water supply (Table 7). The new tariffs will be applied by gradual increase during 2024 - 2028.

Due to climatic peculiarities of the regions of Kazakhstan, different water tariffs are set for each oblast for irrigation water use (Karaganda Regional Maslikhat, 2023; Department of State Revenues for the North Kazakhstan Region, 2023) (Table 8).

Table 7. Tariffs for regulated water supply service through canals

No	Consumer groups	Years,				
		2024	2025	2025	2027	2028
		excluding VAT				
Average tariff, KZT /m³		3.655	5.109	5.170	4.972	5.138
I	**Agricultural producers, KZT/ m³**					
1.1	With mechanized water supply	36.339	50.791	51.403	49.426	51.086
1.2	Gravity water supply	0.956	1.336	1.352	1.300	1.344
II	**Water utilities**					
2.1	With mechanized water supply	28.503	39.839	40.319	38.768	40.070
2.2	Gravity water supply	1.071	1.496	1.514	1.456	1.505

Continuation of Table 7

III	**Electricity generation**					
3.1	With mechanized water supply	62.632	87.540	88.596	85.188	88.049
3.2	Gravity water supply	0.558	0.780	0.789	0.759	0.784
IV	**Water release**					
4.1	With mechanized water supply	43.865	61.309	62.049	59.662	61.666
4.2	Gravity water supply	1.104	1.544	1.562	1.502	1.553
V	**Industrial enterprises**					
5.1	With mechanized water supply	89.877	125.621	127.136	122.245	126.351
5.2	Gravity water supply	7.432	10.388	10.514	10.109	10.449

According to estimations, annual water consumption in car washes and saunas exceeds 200 x 10^6 m^3. The need for the implementation of technologies for the secondary use of water resources, especially in small and medium-sized businesses such as car washes and saunas, is a very important measure that shall be implemented in upcoming years. The use of local wastewater treatment technologies, particularly in car washes, will enable the inclusion of water in the secondary circulation without constant reliance on clean water from centralized drinking water supply system.

Table 8. Agriculture water tariffs for the regions of Kazakhstan

No	Agriculture	Tariff	
		KZT	US dollar
I	For North Kazakhstan regions:		
1.1	Basin of rivers and lakes Balkhash, Alakol	69,32	0,15
1.2	Irtysh River Basin	76,86	0,16
1.3	Ishim River basin	145,73	0,30
1.4	Nura, Sarysu, Kengir river basins	84,39	0,18
1.5	Turgai, Tobol, Irgiz river basins	72,34	0,15
II	Kostanay region	160,4	0,33
III	South Kazakhstan region	5,4	0,01

CHAPTER 5. FUTURE WATER RESOURCE MANAGEMENT

5.1. Water demand for future to satisfy need of consumers

As we discussed in the above sections, the main groups of water consumers in the country include all economic activities, including agriculture, industries and public utilities sectors.

The prospects for hydropower development are determined by the dynamics of changes in the magnitude of river flows in the coming decades.

The eastern part of the country (East Kazakhstan and Pavlodar region) accounts for 41.8 % of all energy resources, the south-eastern part (Almaty region) - 41.5 %, the northern part (Akmola, Kostanay, North Kazakhstan region) – 0.8 %, central (Karaganda region) – 0.8 %, southern (Zhambyl, South Kazakhstan, Kyzylorda region) -13.4 %, and western (Atyrau, Aktobe, Ural region) – 1.6 %. There are three large rivers in Kazakhstan that are already practically used as sources of electricity generation - Ertis, Ile and Syrdarya. The rest are small rivers located mainly in mountainous areas with high gradients. Only small HPPs of mainly derivation type can be built on such rivers. Among the operating large hydropower plants in Kazakhstan, only Bukhtarminskaya HPP has full capacity to cover the peak part of daily load schedules. At Kapshagayskaya HPP there are limitations associated with fluctuations in downstream levels due to fears of flooding of downstream facilities, including in the delta of the Ile River (Kalashnikov, 2012).

On average, from 2020 to 2022, water withdrawal for agriculture amounts to 14.8 x $10^9 m^3$, of which 77% was used for regular irrigation on an area of 1.18 x 10^6 ha., and the remaining 3.61 x $10^6 m^3$ was distributed between firth irrigation, hayfield flooding, agricultural water supply and pasture watering. The largest agricultural water consumer is regular irrigation, for which there is a negative trend of increasing specific water consumption rates from 8.5 m^3/ha. in 2011 - 2022 to 10 m^3/ha.

According to the assessment of “Kazakh Research Institute of Water Management” LLP, this is due to climate change, which affects the increase in the norms of water consumption of agricultural crops water requirements and irrigation norms. Thus, the average number of irrigations during the growing season increased from 5 to 6. And statistical data on water withdrawal volumes and level of unproductive losses show that the most inefficient water use is observed in regular irrigation. The trend in reduction of the water resources and state plans to increase the area of irrigated lands require from the government to put investments for water saving technologies in irrigation, including irrigation upgrading programs to eliminate unproductive water losses and improvement of the overall farming system in the country. These measures will promote environmentally friendly use of land and water resources and overall increasing of the agriculture productivity. This task requires intensive realization of the targeted programs in the regions. Given the impending challenge of water scarcity in the country, careful analysis of the water balance must be carried out by clearly outlining how much water would be consumed by each sector.

5.2. Adaptation measures for the protection and rational use of freshwater resources

The government has set a task to provide 100% of the population with clean drinking water by 2025. Work in this direction is being carried out by the Ministry of Industry and Infrastructure Development (Ayashev, 2023).

For 100% provision of the population with quality drinking water, it is planned to implement 8 projects on construction and reconstruction of group water pipelines. Thanks to these projects it is envisaged to provide 41 rural settlements with 22.3 thousand people with quality drinking water.

The total cost of the projects is 37.8 x 10^9 KZT. Of these, 8.6 x 10^9.KZT is envisaged within the framework of the national budget for 2023 - 2025 for the implementation of 3 projects. The first one is, construction of the branch of connection to Kosaman-Akbasty of Aral-Sarybulak group water pipeline and water supply to Akbasty settlement of Aralsk district of Kyzylorda province. The second project is construction of Aralsk-Tokabay-Abay connection branch of Aralo-Sarybulak group water pipeline and water supply to Tokabay and Abay settlements of Aral district. And the third one is reconstruction of Sokolov group water pipeline and construction of distribution networks of rural settlements with connection.

In agriculture, precision agriculture optimizes return on inputs while preserving resources. Other options include fertilization and improved crop protection to limit pests and diseases. Selective breeding and pasture improvement through rotational grazing aims at avoiding overgrazing and increasing livestock productivity. Improved weather forecasting and early warning systems for extreme weather events can also help to limit the economic losses caused by climate change. Each of these individual techniques can at least partially offset yield losses in drought years. In contrast, insurance against crop failures compensates farmers at least partly, but cannot prevent losses. The techniques require investment in new machinery and equipment, knowledge, and training. Crop farming and livestock technologies are already analyzed regarding their cost and benefits in terms of mitigation and adaptation potential. Cost-benefit-analyses of investments into particular adaptation measures already indicate the value of adaptation benefits derived from them (Table 9) (GIZ, 2021).

Table 9. Cost-benefit-analysis of adaptation measures

Adaptation measures	Investments, mln. USD	Adaptation benefit, mln. USD/year
Drip irrigation of arable lands	83	112
Precision agriculture (parallel driving)	80	10
Investment in field machinery (tractors, harvesters)	1,000	63
Conservation agriculture (no-till farming): investing in modified and direct seeders	263	250
Improved greenhouses	4	1
Pasture improvement through rotational grazing (investment in infrastructure rehabilitation, pasture vegetation needed)	144	70
Fattening units	290	72

5.3. Priority approaches and planned policies

Taking into account the analysis of the current situation, international experience, vision of development of the water resources management system in Kazakhstan for

2024 - 2030 and basic principles, the following approaches are envisaged to achieve the set objectives.

Approach 1. Modernization and development of water infrastructure

In order to ensure uninterrupted water supply to water users and to maintain water infrastructure in proper condition will be:

- A multifactor survey of water management facilities should be carried out, taking into account the development of their safety declaration.
- Reconstruction and repair and rehabilitation of irrigation canals and vertical drainage wells.
- Construction of new reservoirs and reconstruction of emergency reservoirs; measures to adapt the water sector to climate change.
- Introduce automation and digitalization in the system of water resources accounting and management while developing integrated approaches to their rational management.
- Inventory, reconstruction and construction of water flooding facilities on pasture lands.
- Development of own production of water-saving irrigation technologies, water measuring devices and installations.
- Reconstruction and modernization of the Kanysh Satpayev Canal.
- Implementation of measures on guaranteed uninterrupted water supply to the city of Astana.

Approach 2. Improving the efficiency of water resources utilization. In order to maintain the volume of available water resources at an ecologically and economically optimal level, there will be:

- Investigation of best available technologies in the field of protection and use of the water fund;
- Develop new mechanisms for setting water use limits.
- Elaboration of systems of integrated use of surface, ground and collector-drainage water to increase water availability of irrigated lands.
- Installation of recycling and reuse water supply systems and adopt plans for transition to such water supply systems.
- Improvement of design parameters and operation modes of large reservoirs on transboundary rivers.

Approach 3. Improvement of information and analytical support of water resources management system

In order to develop the system of accounting and forecasting of water-resource potential of Kazakhstan, to improve information systems of water resources management and planning will be:

- digitalization and automation of water accounting on main and inter-farm irrigation canals, as well as processes of water resources accounting, control and monitoring on hydraulic structures.
- development of digital geo-service flood- “gharysh.kz” for flood monitoring and forecasting.
- development of interactive geo-information platform on water resources of the Republic of Kazakhstan hydro.gov.kz

- development of a digital platform on water consumption based on Earth remote sensing data and Hydro-Space field verification is underway.

- building new hydrological posts and creating high-altitude snow measuring routes

- monitoring and assessment of ameliorative condition of irrigated lands.

- a set of scientific and analytical works on water resources assessment, development of principles and approaches to decision-making in the management system.

- take measures to organize state monitoring of groundwater and dangerous geological processes.

- assess water resources management, taking into account adaptation to climate change and anthropogenic pressures.

Approach 4. Improving the environmental situation

To preserve and restore natural water bodies, we will:

- develop rational wastewater treatment schemes; develop quality standards for surface water bodies.

- develop rehabilitation programs for small rivers; clean up rivers and lakes.

- implement a set of measures for the restoration of the Northern Aral Sea.

- take measures to preserve the Kokaral dam and restore the delta of the Syrdarya River.

- inventory of sources of pollution of water bodies are carried out.

- comprehensive studies on the Caspian Sea were carried out; environmental releases are being carried out.

- Craning (installation of shut-off valves on wells) of orphaned self-injecting hydrogeological wells is carried out.

- Expansion of observation well network for monitoring and assessment of reclamation condition of irrigated lands.

Approach 5. Developing cross-border cooperation

For development of interstate water relations will be:

- agreements on transboundary water bodies were signed with the People's Republic of China and the Republic of Uzbekistan.

- The mechanism of water-energy cooperation of Central Asia (Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, Uzbekistan) for rational use of water-energy resources of the Aral Sea region has been developed.

- Strengthening the competence of members of negotiating groups on the use and protection of transboundary water bodies.

Approach 6. Improvement of the regulatory legal framework, provision of scientific and methodological documentation

In order to improve water legislation in accordance with modern legal, economic, and environmental relations in the country there will be:

- updating basin plans for integrated water resources management.

- updating aggregated norms of water consumption and water disposal.

- inducing efficient water use by individuals, agrarians and enterprises.

-reforming of water management systems of the country, including "resetting" of key companies of the sectors (RGP on PCW "Kazvodkhoz", "Nura group water pipeline" and others) with material and personnel strengthening of the whole sector.

Approach 7. Staffing in the water sector

- increasing the human resource potential of the water sector, to improve training of highly qualified personnel will be:
- updating the educational programs, should include; innovative disciplines.
- taking measures to develop dual-diploma and joint educational programs in the water sector with foreign partner universities.
- opening of branches of university departments on the basis of water industry enterprises.

The country's economy in the future will require an increase in the guaranteed volume of water resources of appropriate quality to meet drinking and domestic needs, as well as for use in industry, agriculture, energy and recreational purposes.

The only ways to improve this situation are well-established management of the balance between available resources and consumption, as well as water quality management.

CHAPTER 6. CONCLUSION AND POLICY RECOMMENDATIONS

6.1. Addressing water scarcity, pollution, and future sustainability

Water resources of the Republic of Kazakhstan are limited due to location of the country, high demand of shared water resources by the neighboring countries and their reduction due to the climate change. There is a regional deficit in some river basins, resulting in losses in the fishing industry and agriculture, degradation of lakes, rivers, and wetlands.

Expected trends of increasing water consumption and decreasing water availability threaten to increase regional scarcity, which six out of eight water basins in Kazakhstan may face by 2030. Unless the efficiency of water use and management is improved, water scarcity will worsen by 2040, adversely affecting water supply, GDP growth and the environment. Many problems of water supply are caused by poor water quality of some rivers (Ilek, Kara-Kengir and others), low technical condition of existing hydraulic structures, canals, pipelines and others.

Economic and social development in Kazakhstan is largely determined by the sustainability of the water sector and its institutional and legal support. Kazakhstan has a significant potential of the water sector and established institutional structure capable to ensure sustainable functioning of the water sector under sufficient legal, financial, scientific, technical and personnel support.

Integrated water resources management is a means to achieve key strategic objectives such as efficient use of scarce water resources, equitable allocation of water resources and increased sustainability of aquatic ecosystems. Integrated water resources management is a process that promotes the coordinated development and management of water, land and other resources to maximize social and economic welfare in an equitable manner without compromising the sustainability of vital ecosystems. Thus, an integrated water resources management plan can be seen as a plan for the development and management of water resources, which will include components such as an enabling legal environment, organizational environment and management tools.

Water resources protection is one of the most complicated problems of water management. The main cause of surface water pollution is the discharge of untreated industrial and municipal wastewater into rivers and water bodies. In order to preserve and restore the water bodies, it is advisable: i) to improve and change the technology of industrial and agricultural production. ii) develop and implement low-water and waterless technology in order to reduce the volume of water discharge. iii) ensure full treatment of municipal and industrial wastewater. iv) broad introduction of recycled water supply, expansion of reuse of treated wastewater discharges into rivers.

6.2. Policies and measures for water sector development until 2030

By 2030, significant improvements are expected to be implemented in the water sector of Kazakhstan - reduction of unproductive losses during water transportation, development of hydrogeological and reclamation monitoring system to improve the condition of irrigated lands, improvement of technical condition of hydraulic structures for guaranteed water supply to economic sectors and reduction of threats of emergencies.

The main attention will be given measures for enlargement of water-saving irrigation technologies, which will allow saving up to 30% of irrigation water. The released water will be used for farming additional irrigated areas and significantly increasing the productivity of water resources.

Wide utilization of treated wastewater will reduce the anthropogenic load on water bodies. Implementation of the measures for rational use of available water resources, will lead to transition from "resource management" to "demand management". To improve the system of water resources management, improved system of state monitoring of sub-terrestrial waters was restored; establishment of the precise data collection and analysis system; development of forecasts and ecologically, economically and politically sound plans for timely response to water security challenges and threats based on the results of the scientific investigations.

Improvement of transboundary water bodies' management taking into account the interests of the all involved countries is necessary, which will strength cooperation with the riparian countries.

Legislative regulation of water-resource potential of the country will create sustainable management frameworks and requirements for protection and use of the water fund, water conservation, economic mechanism of regulation, interstate cooperation on transboundary watercourses, and prevention of harmful impact as a basis for water security.

The human and scientific potential of the water sector will be increased by improving training and attracting highly qualified personnel, increasing salaries, social security of young specialists (provision of rental housing, lump-sum payments, lifting allowances, housing or monthly housing payments), development of science and provision of modern training, laboratory, material and technical base.

Thus, the future water security of Kazakhstan in the context of climate change will depend on how the country responds and diligently takes measures to make water available to all sectors of the economy in sufficient quantity and quality, considering environmental requirements for water use and water protection.

6.3. Outline of roadmap for sustainable water management and development

Kazakhstan faces significant challenges related to water scarcity, aging infrastructure, and the impacts of climate change. To address these issues and ensure sustainable water resources for future economic development, the country will need a multi-faceted strategy. Important key recommended actions for the country can be summarized as below:

1. Modernizing Irrigation Systems:

Upgrade Infrastructure: Invest in modern irrigation technologies such as drip and sprinkler systems to reduce water losses and increase efficiency.

Implement Water-Saving Techniques: Adopt practices such as precision irrigation and soil moisture monitoring to optimize water use.

2. Enhancing Water Management and Governance:

Integrated Water Resources Management (IWRM): Develop and implement a comprehensive IWRM plan that considers the needs of all sectors and promotes efficient and equitable water use.

Strengthen Cross-Border Cooperation: Strength cooperation with neighboring countries to manage shared transboundary water resources collaboratively, ensuring fair allocation and reducing conflicts.

3. Improving Water Supply and Sanitation:

Upgrade Facilities: Replace or refurbish aging water supply and sanitation infrastructure to reduce losses, enlarge service area and improve service quality.

Promote Efficient Water Use: Encourage practices and technologies that reduce water consumption in households and industries.

4. Investing in Climate Resilience:

Climate-Resilient Infrastructure: Design and construct infrastructure that can withstand the impacts of climate change, such as extreme weather events and altered precipitation patterns.

Enhance Water Storage: Develop or upgrade reservoirs and other water storage facilities to capture and store water during periods of surplus.

5. Promoting Sustainable Agriculture:

Adopt Sustainable Practices: Encourage the use of conservation tillage, crop rotation, and other practices that enhance soil health and water retention.

Support Research and Innovation: Invest in research to develop drought-resistant crops and other technologies that improve water use efficiency in agriculture.

6. Public Awareness and Education:

Raise Awareness: Educate the public and stakeholders about the importance of water conservation and sustainable practices.

Engage Communities: Involve local communities in water management decisions and initiatives to ensure that solutions are practical and widely accepted.

7. Monitoring and Data Collection:

Improve Data Collection: Invest in technology and systems to monitor water usage, quality, and availability more effectively.

Utilize Data for Decision-Making: Use collected data to inform policies and manage water resources more effectively.

8. Legislative and Policy Framework:

Update Regulations: Review and update water management regulations to address current challenges and incorporate new technologies and practices.

Incentivize Conservation: Provide financial incentives or subsidies for practices and technologies that reduce water consumption and increase efficiency.

9. International Cooperation and Funding:

International Support: Engage with international organizations and donor agencies for technical and financial support.

Participate in Global Initiatives: Join global initiatives and agreements focused on water sustainability and climate change adaptation.

Overall, Kazakhstan will need to invest huge amounts to address its water challenges comprehensively. Collaboration with international partners and strategic planning will be crucial for securing the necessary funding and ensuring effective implementation of these measures. Exchange of knowledge and experiences, realization of the joint projects with the Turkic States will promote policies and achieve successful realization of the planned policy measures under the rapidly changing environment.

References

1. Ayashev M. (2023). Eight projects are being implemented to provide water in Kazakhstan. International Information Agency «Kazinform. (Восемь проектов реализуют для обеспечения водой в Казахстане. Интервю от 28 апреля 2023 г.) https://www.inform.kz/ru/vosem-proektov-realizuyut-dlya-obespecheniya-vodoy-v-kazahstane_a4061659

2. Association of Practicing Ecologists (2023). Analytical report. State of sewage treatment facilities in Kazakhstan. (Аналитический доклад. Состояние канализационных очистных сооружений в Казахстане). https://ecounion.kz/wp-content/uploads/2023/04/Аналитический-доклад-по-очистным-сооружениям-КОС-в-Казахстане.pdf

3. Askarova, M. A., Medeu, A. A., Medeu, A., & Mussagaliyeva, A. N. (2021). Adaptive model of the impact of climate change on natural and economic systems of Kazakhstan (Адаптивная модель влияния изменения климата на природно-хозяйственные системы Казахстана. Вестник КазНУ. Серия географическая, 60(1), 52-60). Vestnik KNU, Geography series, 60(1), 52-60.

4. Astana Su Arnasy (2024). Tariffs for water supply and sanitation for the period from August 1, 2024 to December 31, 2024. https://astanasu.kz/to-client/tariffs/

5. Department of State Revenues for the North Kazakhstan Region (2023). About rates of payment for use of water resources from surface sources in North-Kazakhstan region for 2023. Decision of the North Kazakhstan Regional Maslikhat dated April 17, 2023 No. 2/5. (О ставках платы за пользование водными ресурсами из поверхностных источников по Северо-Казахстанской области на 2023 год. решение Северо-Казахстанского Областного Маслихата от 17 апреля 2023 года №2/5.) https://www.gov.kz/memleket/entities/kgd-sko/press/article/ details/1237 19?lang=ru

6. Boretti, A., & Rosa, L. (2019). Reassessing the projections of the world water development report. NPJ Clean Water, 2(1), 15. https://www.nature.com/articles/s41545-019-0039-9

7. Genina, M. (2007). The development of a new water code in the Republic of Kazakhstan. Politikon: The IAPSS Journal of Political Science, 13(1), 21-31.

8. GoK (2003). Water Code of the Republic of Kazakhstan. Information-legal system of normative legal acts of the Republic of Kazakhstan “Ədilet” (2003).

9. GoK (2014). State Water Resources Management Program of Kazakhstan, (2014). (Государственная программа управления водными ресурсами Казахстана. Указ Президента Республики Казахстан от 4 апреля 2014 года № 786). https://adilet.zan.kz/rus/docs/U1400000786 /compare

10. GoK (2016). General scheme of integrated use and protection of water resources (Генеральная схема комлексного использования и охраны водных ресурсов. Утверждена постановлением Правительства Республики Казахстан № 200 от 8 апреля 2016 года, 2016). https://primeminister.kz/assets/media/pr-200-ru.pdf

11. GOK (2018). State Program for the Development of Agro-Industrial Complex of the Republic of Kazakhstan for 2017 - 2021 year. Resolution of the Government of the Republic of Kazakhstan dated July 12, 2018 № 423. Information-legal system of normative legal acts of the Republic of Kazakhstan “Ədilet”. https://adilet.zan.kz/rus/docs/P1800000423

12. GoK (2021). National Project “Green Kazakhstan. Resolution of the Government of the Republic of Kazakhstan dated October 12, 2021 № 731. Information-legal system of normative legal acts of the Republic of Kazakhstan “Ədilet”. https://adilet.zan.kz/rus/docs/P2100000731

13. GoK (2023). Consolidated analytical report on the condition and use of lands of the RK for 2023 (Сводный аналитический отчет о состоянии и использовании земель РК за 2023 год). http://cawater-info.net/bk/land_law/files/kz-land2023.pdf

14. GoK (2024). Concept of development of water resources management system of the Republic of Kazakhstan for 2024-2030 (Концепция развития системы управления водными ресурсами Республики Казахстан на 2024-2030 годы. Постановление Правительства Республики Казахстан от 5 февраля 2024 года № 66.). https://adilet.zan.kz/rus/docs/P2400000066

15. GIZ (2021). Kazakhstan: Economy-wide Effectsof Adaptation in Agriculture https://www.giz.de/de/downloads/giz2021-en-kazakhstan-policy-brief-agriculture.pdf

16. Karimov E. (2023). Water issue in Kazakhstan: problems and solutions (Водный вопрос в Казахстане: проблемы и пути решения). Ulysmedia. https://ulysmedia.kz/news/15569-vodnyi-vopros-v-kazakhstane-problemy-i-puti-resheniia

17. Kazgidromet (2023). Annual Bulletin of Monitoring and Status and Climate Change of Kazakhstan in 2022. Astana, 2023 (Ежегодный бюллетень мониторинга состояния и изменения климата Казахстана: 2022 год. Астана, 2023). https://www.kazhydromet.kz/ru/klimat/ezhegodnyy-byulleten-monitoringa-sostoyaniya-i-izmeneniya-klimata-kazahstana

18. Kazvodkhoz (2023). Order 94-OD dated 13.11.2023 on approval of tariffs and tariff estimates. (Об утверждении тарифов и тарифной сметы республиканскому государственному предприятию на праве хозяйственного ведения «Казводхоз» Комитета водного хозяйства Министерства водных ресурсов и ирригации Республики Казахстан на регулируемую услугу по подаче воды по каналам) https://www.gov.kz/memleket/entities/krem/documents/details/ 551561 ?lang=ru

19. Kalashnikov A. (2012). Water Consumption by economic sectors of Kazakhstan: Assessment and Forecast (А.А. Калашников Водопотребление отраслями экономики Казахстана: Оценка и прогноз, 2012. Национальный научный портал Республики Казахстан). https://cyberleninka.ru/ article/n/vodopotreblenie-otraslyami-ekonomiki-kazahstana-otsenka-i-prognoz

20. Karaganda Regional Maslikhat (2023). On approval of the rates of payment for the use of water resources from surface sources of Karaganda region for 2023 (Об утверждении ставок платы за пользование водными ресурсами из поверхностных источников Карагандинской области на 2023 год. Утверждены решением Карагандинского областного маслихата от 18 апреля 2023 года № 32). Information-legal system of normative legal acts of the Republic of Kazakhstan �dilet. https://adilet.zan.kz/rus/docs/V23K0638309

21. Kabzhalalova M. (2024). Restoration of the water resources system - who will finance? (Восстановление системы водных ресурсов –кто будет финансировать? Мадина Кабжалялова – Аналитический центр,2 февраля 2024 года) Analytical center Halyk Research. https://halykfinance.kz/download/files/analytics/ac_water.pdf

22. Koldasova, L.& Aydarova, L. (2021). Investments in water management of the Republic of Kazakhstan (Колдасова, Л. С., Айдарова, А. Б. Вложений инвестиций в водное хозяйство республики Казахстан. Материалы международной научно-практической онлайн конференции «Инвестиционная привлекательность в обеспечении экономической стабильности стран: глобальные проблемы и пути их решения». (Ташкент, 14 мая 2021 г.) ТГЭУ, Узбекистан. 2021. с.502-506

23. Kurmanbekov A., Kabzhalalova M., Kaldarov S. (2023). Review of agricultural development in Kazakhstan. JSC "Halyk Finance". https://halykfinance.kz/download/files/analytics/AC_ agriculture _ development.pdf

24. Kipshakbayev N. (2014). Management of water use and protection. (Управление использованием и охраной вод. Монография. Издательство ТОО «Типография Форма Плюс», 452 с.) Astana, ISBN 978-601280-236-9.

25. Mataev T. (2020, 10 June). On the development of PPP in Kazakhstan: status, trends and prospects (О развитии ГЧП в Казахстане: состояние, тенденции и перспективы. Интервью Председателья Правления АО «Казахстанский центр государственно-частного партнерства» Талгат Матаева в PrimeMinister.kz). https://www.gov.kz/memleket/entities/economy/press/news /details/70891?lang=en

26. Metito (2023). Metito inks historic agreement to pioneer Public-Private Partnerships in the water sector in Kazakhstan. https://www.metito.com/news-detail/metito-inks-historic-agreement-to-pioneer-public-private-partnerships-in-the-water-sector-in-kazakhstan/

27. Ministry of National Economy (2024). On Approval of the Rules of Tariff Formation. Order of the National Economy of the Republic of Kazakhstan from January 26, 2024 № 1(Приказ Министерства Национальной Экономики Республики Казахстан от 26 января 2024 года №1 «Об утверждении Правил формирования тарифов»). https://online.zakon.kz/Document/?doc_id= 35678895 &show_di=1

28. Myrzahmetov, M. M., & Ryskulbekova, L. M. (2013). Ways of improving efficiency of wastewater treatment for agriculture. Ekonomia i Środowisko, (4), 266-275.

29. Nikolaenko A.Y., Ibatullin S. R., Vinogradov S.V. Policy review and recommendations for the Republic of Kazakhstan in the field of transboundary water resources management (2016). (Обзор политики и рекомендации для Республики Казахстан в сфере управления трансграничными водными ресурсами. Астана). Joint EU/UNDP/UNECE Project "Supporting Kazakhstan to Transition to a Green Economy Model" https://unece.org/fileadmin/DAM/env/water/meetings/ Water_Convention/2016/Projects_in_Central_Asia/ReviewTransboundCooperation_Kazakhstan_RUS_FINAL.pdf

30. Turmagambetov M.A., Orman A.O., Burlibayev M.J. and others. (2011). Comparative-legal analysis of water legislations of states bordering Kazakhstan and preparation of recommendations for harmonization of transboundary river management mechanism (Сравнительно-правовой анализ водных законодательств сопредельных с Казахстаном государств и подготовка рекомендаций для гармонизации механизма управления трансграничными реками. Издательство «Каганат», Алматы, 2011).

31. Tonkonog O. (2024). Kazakhstan wants to attract more than 500 billion tenge of investments from the Islamic Development Bank for water projects (Казахстан хочет привлечь более 500 млрд тенге инвестиций от Исламского банка развития на водные проекты. Статья от 24 июня 2024 г. Международное деловое электронное издание Курсив). International business electronic publication Kursiv. https://kz.kursiv.media/2024-06-24/lgtn-water-3/

32. Tokayev K. (2021). Unity of the people and systemic reforms are a solid basis for the country's prosperity. Message from the Head of State Kassym-Jomart Tokayev to the people of Kazakhstan (Единство народа и системные реформы – прочная основа процветания страны. Послание Главы государства Касым-Жомарта Токаева народу Казахстана от 01 сентября 2021 года). https://www.akorda.kz/ru/poslanie-glavy-gosudarstva-kasym-zhomarta-tokaeva-narodu-kazahstana-183048

33. Tokayev K. (2023). Economic course of Fair Kazakhstan. Message from the Head of State Kassym-Jomart Tokayev to the people of Kazakhstan (Послание Главы государства Касым-Жомарта Токаева народу Казахстана «Экономический курс Справедливого Казахстана. г. Астана, 1 сентября 2023 года). https://online.zakon.kz/Document/?doc_id=37321590&pos=5;-109#pos=5;-109

34. Tursunova, A., Medeu, A., Alimkulov, S., Saparova, A., & Baspakova, G. (2022). Water resources of Kazakhstan in conditions of uncertainty. Journal of Water and Land Development, (54), 138-149. https://www.giz.de/de/downloads/giz2021-en-kazakhstan-policy-brief-agriculture.pdf

35. Tyumenev S. (2008). Water resources and water availability in Kazakhstan (Водные ресурсы и водообеспеченность территории Казахстана. Учебник. Алматы, КазНТУ, 267 с.).

36. UNDP & EU (2017). Review of the main challenges of the river basin principles implementation in Kazakhstan and recommendations. Improving the effectiveness of river basin management". Water management challenges and recommendations (Повышение эффективности управления речными бассейнами. Проблемы в области управления водными ресурсами и рекомендации. Астана, 2017). https://unece.org/fileadmin/DAM/env/water/meetings/ Water_Convention/2016/Projects_in_Central_Asia/Review_of_the_main_challenges_of_the_river_basin_principles_implementation_in_Kazakhstan_and_recommendations.pdf

37. UNDP (2021). How climate change affects water resources. (Как изменение климата влияет на водные ресурсы. Статья. от 26.10.2021 г.). https://www.undp.org/ru/kazakhstan/stories/kak-izmenenie-klimata-vliyaet-na-vodnye-resursy-kazakhstana

38. Watermagazin.ru (2023). Construction of a new seawater desalination plant has begun in Kazakhstan. https://watermagazine.ru/novosti/za-rubezhom/28686-v-kazakhstane-nachalos-stroite lstvo-novogo- zavoda-po-opresneniyu-morskoj-vody.html

39. WMC (2024). Regulations on the Water Management Committee of the Ministry of Water Resources and Irrigation of the Republic of Kazakhstan, 2024 (Положение о комитете водного хозяйства Министерства водных ресурсов и ирригации Республики Казахстан, 2024). https://www.gov.kz/memleket/entities/komwater/about?lang=ru

40. WB (2024). Kazakhstan. General Water Security Assessment. https://documents1. worldbank.org/curated/en/099062424121021579/pdf/P1700301c580430118aca1917d53b41c92.pdf

41. Yespolov T. (2016) Innovative directions of development of watering and water supply of pasture territories of the Republic of Kazakhstan (Инновационные направления развития обводнения и водоснабжения пастбищных территорий Республики Казахстан. Журнал Вопросы географии и геоэкологии, №3, 2016. -с.17). https://staff.tiiame.uz/storage /users/732/articles/qsK9dVPlsz1XNk4mGrGQ4jzjxdFifJtFvhJd6Jzl.pdf

42. Yespolov, T. I., Tireuov, K. M., & Kerimova, U. K. (2022). Water resources in agriculture of the Republic of Kazakhstan: scientists' view on rational use, perspectives and management. Journal of agro-market problems, No. 3. (Водные ресурсы в сельском хозяйстве Республики Казахстан: взгляд ученых на рациональное использование, перспективы и управление. Журнал Проблемы агрорынка, №3, 2022.). https://www.jpra-kazniiapk.kz/jour/article/view/975/555


KYRGYZSTAN

LIST OF ABBREVIATIONS

ADB	Asian Development Bank
CM	Chairperson of the Cabinet of Ministers
CMIP	Coupled Model Intercomparison Project
CMIP5	Phase 5 of the Coupled Model Intercomparison Project
CMIP6	Phase 6 of the Coupled Model Intercomparison Project
DSSES	Department of State Sanitary and Epidemiological Surveillance
DWMA	District Water Management Associations
EBRD	European Bank for Reconstruction and Development
FAO	Food and Agriculture Organization (of the United Nations)
GDP	Gross Domestic Product
GFDRR	Global Facility for Disaster Reduction and Recovery
I&D	Irrigation and drainage
IFAD	International Fund for Agricultural Development
IFAS	International Fund for Saving the Aral Sea
IWRM	Integrated Water Resources Management
MES	Ministry of Emergency Situations
MHSD	Ministry of Health and Social Development
MNRETS	Ministry of Natural Resources, Environment and Technical Supervision
NWRMP	National Water Resources Management Project
ODA	Official Development Assistance
OECD	Organisation for Economic Co-operation and Development
PPP	Public-Private Partnership
RCP	Representative Concentration Pathway
SDG	Sustainable Development Goal
SECO	Swiss State Secretariat for Economic Affairs
SWS	State Water Service
UNECE	United Nations Economic Commission for Europe
UNFC	United Nations Framework Classification for Resources
WUA	Water Users Association

EXECUTIVE SUMMARY

Kyrgyz Republic (Kyrgyzstan), situated in Central Asia, is a landlocked country spanning a total area of 199,949 km^2. The country shares borders with Kazakhstan to the north, China to the east and southeast, Tajikistan to the southwest, and Uzbekistan to the west. Following its independence from the Former Soviet Union in August 1991, Kyrgyzstan has been divided into seven provinces, namely Batken, Chu, Djalal-Abad, Issyk-Kul, Naryn, Osh, and Talas. With its predominantly mountainous terrain, the country is characterized by the western stretches of the Tien Shan range in the northeast and the Pamir-Alay in the southwest.

Situated at the heart of the Central Asian “water tower” Kyrgyzstan is home to the Syr Darya and Amu Darya River basins, which originate from the Pamir and Tien Shan Mountain ranges. The country’s water resources significantly contribute to the annual flow of these transboundary rivers, positioning Kyrgyzstan as a key player in the regional water management landscape.

However, the region faces challenges such as diminishing water resources due to climate change, ineffective management, and cross-border water use issues among the Central Asian states. Kyrgyzstan boasts a diverse range of water resources, including perennial and ephemeral rivers, brooks, springs, freshwater and brackish lakes, and substantial groundwater reserves. The country’s hydrological landscape can be divided into two main zones: the flow generation zone, which encompasses 87% of the territory, and the flow dissipation zone, covering the remaining 13%.

The Syr Darya river basin, which includes the Naryn river within Kyrgyzstan, plays a significant role in the country’s water resources, accounting for 55.3% of its territory. Other major river basins include the Chu, Talas, and Assa, which encompass approximately 21.1% of Kyrgyzstan’s area, and the southeastern river basins, which drain into the Tarim basin in China, covering around 12.9% of the country’s territory. The internal and interior basin of Lake Issyk-Kul, a unique freshwater lake, accounts for 6.5% of Kyrgyzstan’s land area, while the Amu Darya river basin covers 3.9% of the country’s territory.

Kyrgyzstan boasts an impressive number of lakes, with a total of 1923 scattered throughout its territory. The Issyk-Kul, Son-Kul, and Chatyr-Kul lakes stand out as the largest, holding considerable water reserves, estimated at around 1,745 km^3. However, most of these reserves (99.2%) are concentrated in the saline Issyk-Kul Lake, limiting its direct use for domestic, industrial, or agricultural needs.

In terms of long-term average river runoff, Kyrgyzstan is estimated to have around 48.6 km^3 of renewable water resources annually. The country’s water structure reveals that agricultural water use constitutes the highest share, accounting for 94-96% of total water consumption, followed by industrial and municipal domestic water use. Kyrgyzstan also has substantial groundwater resources, with 10^6 identified groundwater fields and projected reserves of over 13 km^3 per year.

Despite its abundant water resources, Kyrgyzstan only withdraws around 7-8km^3 of surface water for its own economic needs, with the vast majority used for irrigated agriculture. Groundwater resources have become increasingly important, supplying drinking and municipal water and accounting for 0.2-0.3 km^3 per year of water abstraction. Hydropower generation, which accounts for 90% of Kyrgyzstan's electricity production, is the largest consumer of water, using up to 12 km^3 per year, often in conflict with the water needs of the agricultural sector.

The institutional framework for water management in Kyrgyzstan is centred around the Ministry of Water Resources, Agriculture and Processing Industry, which oversees the implementation of the state's water policy. The Water Resources Agency, a subordinate division of the Ministry, is responsible for managing, monitoring, and regulating the state and use of water resources. Other key agencies involved include the Ministry of Natural Resources, Environment and Technical Supervision, the State Water Service, and local authorities.

Kyrgyzstan has been making efforts to reform its water sector, including the introduction of a new Public-Private Partnership (PPP) law in 2021 and the development of a National Water Strategy. The strategy aims to establish a multi-layered system for water resource management, addressing the dynamic growth in water demand, the risk of water scarcity and depletion, water pollution, and the need for transboundary cooperation. However, the country faces significant financing challenges, with the current annual financing of around 168 million USD falling short of the estimated 280 million USD needed. To address these challenges, Kyrgyzstan plans to introduce economic instruments, such as fees for the use of surface water resources in industrial activities and a new permitting system for surface water use. The country also aims to reform irrigation water tariffs, moving towards a more volumetric and differentiated pricing system to incentivize efficient water use and improve cost recovery.

Regarding the impacts of climate change, Kyrgyzstan is facing significant challenges, including rising temperatures, changes in precipitation patterns, and the depletion of glaciers, which are the primary source of the country's water supply. These climate-induced changes are expected to have far-reaching consequences for the agricultural sector, water supply and sanitation, and the hydropower industry, necessitating the development of comprehensive adaptation strategies.

In the agricultural sector, climate change is projected to have both direct and indirect effects on crop growth and productivity. While some regions may experience productivity gains in certain crops, the overall outlook is mixed, with the potential for declines in the yields of staple crops like wheat, maize, and sugar beets. The livestock industry is also susceptible to the impacts of climate change, particularly through changes in the productivity of pasture lands.

The long-term depletion of glaciers and more erratic precipitation patterns are likely to lead to a decrease in overall water supply in Kyrgyzstan, exacerbating existing challenges in meeting water demands for agriculture, industry, and domestic use. This could have significant consequences for the country's water security and the well-being of its population, particularly in the face of rising water tariffs that may disproportionately burden the poor.

The reliance on hydropower in Kyrgyzstan's energy sector also makes it highly vulnerable to the effects of climate change. Projected changes in precipitation patterns, glacial melt, and shifting river flow regimes could significantly disrupt the reliable supply of water resources required to maintain stable hydropower production, necessitating the diversification of the country's energy mix (Shabolotova, 2020).

To address these multifaceted challenges, Kyrgyzstan has initiated various programs and projects, such as the National Water Resources Management Project (NWRMP), which focuses on rehabilitating and upgrading irrigation and drainage infrastructure, strengthening institutional capacities for IWRM, and promoting the use of water-efficient technologies. The government has also been working to diversify crop patterns and introduce more climate-resilient agricultural practices to enhance the sector's resilience.

Recommendations for Kyrgyzstan's water management include the implementation of an Integrated Water Resources Management (IWRM) approach, strengthening water resource monitoring and accounting systems, and addressing the vulnerabilities posed by climate change. Engaging the private sector through PPP initiatives and improving transboundary cooperation on shared water resources are also crucial for the country's sustainable water management.

Recognizing the importance of transboundary cooperation, Kyrgyzstan has made efforts to strengthen its water diplomacy capabilities and engage in constructive dialogue with neighbouring countries. The successful examples of the Agreement on the Use of Water Management Facilities of Intergovernmental Status on the Chu and Talas Rivers between Kyrgyzstan and Kazakhstan, as well as the recent agreements on the joint management of the Orto-Tokoi and Kempir-Abad reservoirs with Uzbekistan, demonstrate the country's commitment to promoting sustainable and equitable water resource management in the region.

Looking ahead, Kyrgyzstan's legal policy in the field of transboundary water management should continue to focus on settling relations with neighbouring states through the conclusion of bilateral international agreements. Considering the fundamental importance of international watercourses for the development of the economies in the region, there may be a need to explore the possibility of creating a supranational interstate structure to ensure the environmentally safe, politically equitable, and economically mutually beneficial exploitation of water resources in Central Asia.

CHAPTER 1. WATER AVAILABILITY, ABSTRACTION, AND DELIVERY

Kyrgyzstan boasts a diverse range of water resources, consisting of perennial and ephemeral rivers, brooks, springs, freshwater and brackish lakes. Notably, the country is home to the second-largest high-mountain lake in the world, Issyk-Kul. The hydrological landscape of Kyrgyzstan can be divided into two main zones: the flow generation zone, which encompasses 171,800 km^3 or 87% of the territory, and the flow dissipation zone, covering 26,700 km^3 or 13% of the territory. Most rivers in Kyrgyzstan are primarily fed by glacier and snow melt. The peak flow periods occur between April and July, spanning around 120-180 days and sometimes extending into August or September.

Water resources in Kyrgyzstan serve various purposes, including irrigation, industrial and domestic water supply, and energy generation. The country's water resources are concentrated in glaciers, lakes, rivers, and groundwater. Glaciers in the Tien-Shan Mountains play a crucial role in freshwater supply for irrigation, households, and energy in Kyrgyzstan and neighboring countries (Tricht et al., 2020). As of 2010, the estimated total glacial volume was approximately 390 x 10^9 m^3 (Pfeffer et al., 2014). Over the past 50-60 years, the glaciers of the Tien-Shan and Pamir have decreased from 60 to 40% (Farinotti et al., 2015). This highlights the ongoing impact of climate change on the availability and sustainability of water resources in Kyrgyzstan.

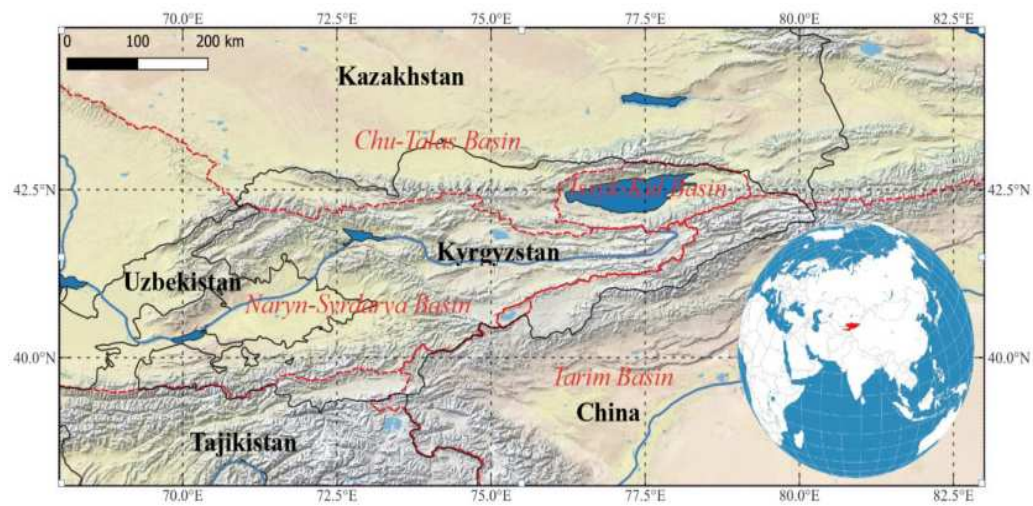


Figure 1. Kyrgyzstan map with main water basins

The Syr Darya river basin, encompassing 55.3% of Kyrgyzstan, plays a significant role in the country's water resources (Figure 1). Within Kyrgyzstan, the river is referred to as the Naryn River until it reaches the Fergana valley. From there, it continues its journey into Uzbekistan, where it transforms into the Syr Darya River. The river then flows into Tajikistan before returning to Uzbekistan. Along its course, it receives the Chatkal River, a tributary that also originates in Kyrgyzstan. Eventually, the Syr Darya River continues its path towards Kazakhstan, contributing to the water supply and irrigation needs of multiple countries in the region. The flow of the Syr Darya River is of vital importance for agricultural activities and the overall water balance within Kyrgyzstan and its neighboring countries.

The river basins of Chu, Talas, and Assa encompass approximately 21.1% of Kyrgyzstan's territory. These rivers have their origins within the country and flow towards Kazakhstan.

The southeastern river basins, encompassing approximately 12.9% of Kyrgyzstan's territory, are distinct from other river systems in the country. These basins drain into the Tarim basin, which is located in China. The main rivers in this region include the Aksu (also known as Sary Dzhaz), Aksay (also known as Toshkan), and Kek Suu. These rivers are situated at high elevations, adding to the unique characteristics of the south-eastern river basins.

The internal and interior basin of Lake Issyk-Kul encompasses approximately 6.5% of Kyrgyzstan's territory. This stunning lake is known for its unique characteristic of having low salinity. The water flowing from various rivers into the Issyk-Kul Lake basin is of great importance, as it provides a vital source of irrigation and water supply for municipalities within the region.

The Amu Darya River basin, which encompasses approximately 3.9% of Kyrgyzstan's territory, is an important river system in the region. While the main source of the Amu Darya River is in Tajikistan, it also receives a significant contribution from the Kyzyl Suu tributary, originating in the southwest of Kyrgyzstan. This highlights the interconnectedness of water resources between countries and the role that Kyrgyzstan plays in the overall hydrological balance of the Amu Darya River basin. The Lake Balkhash basin covers a smaller portion, approximately 0.3%, of Kyrgyzstan's territory.

1.1. Available water resources and water balance

The Kyrgyz Republic boasts an impressive number of lakes, with a total of 1,923 lakes scattered throughout its territory. Among these lakes, the Issyk-Kul, Son-Kul, and Chatyr-Kul stand out as the largest ones. Together, these lakes hold considerable water reserves, estimated at around 1,745 x $10^9 m^3$.

However, it is important to note that 1,731 x $10^9 m^3$ or 99.2% water reserves of the total volume, are concentrated in the Issyk-Kul Lake. But the water in Issyk-Kul Lake is saline and unsuitable for direct water supply purposes, which limits for domestic, industrial, or agricultural usage.

The mountainous terrain of the Kyrgyz Republic has a significant role in shaping its extensive river network. With approximately 5,000 rivers and 2 closed lakes (Issyk-Kul and Chatyr-Kul), the country's river systems are prominent features of its landscape. However, it is worth noting that the river runoff from these inland lakes constitutes only about 3.5% of the total runoff.

In terms of long-term average river runoff, which refers to the cumulative annual flow, it is estimated to be around 48.6 x $10^9 m^3$ (Betz et al., 2022). The water structure in

Kyrgyzstan reveals that agricultural water constitutes the highest share, with irrigation water making up 94% to 96% of total water consumption, followed by industrial and municipal domestic water (Li et al., 2021). This indicates the substantial water resources available from the rivers in the Kyrgyz Republic, which play a vital role in sustaining various sectors such as agriculture, energy generation, and domestic water supply.

Understanding the distribution and characteristics of these lakes and rivers is crucial for effective water resource management in the Kyrgyz Republic, ensuring the sustainable utilization of available water and addressing the water needs of the population and various economic activities.

Table 1: Renewable water resources and water balance of Kyrgyzstan

Variable	Value	Unit
Precipitation (averaged)	533	mm/year
Area of the country	19.995	1000 ha
Precipitation (total)	106.6	km^3/year
Surface water: produced internally	46.46	km^3/year
Groundwater: produced internally	13.69	km^3/year
Total internal renewable water resources	48.93	km^3/year
Surface water leaving the country	41.87	km^3/year
Outflow secured through treaties	25.87	km^3/year

Source: FAO,2012. AQUASTAT Country Profile – Kyrgyzstan

The outflow of water from Kyrgyzstan to its neighboring countries plays a significant role in the region's water resource management. According to available data (Table 1), the Amu Darya River contributes an outflow of approximately 1.51 x 10^9 m^3 per year to Tajikistan. This outflow is crucial for Tajikistan's water supply and agricultural needs, supporting the livelihoods of the population in that country.

Similarly, the Syr Darya River, with an outflow of approximately 22.33 km^3 per year, provides a substantial water supply to Uzbekistan. This flow is of vital importance for Uzbekistan's agricultural sector, contributing to irrigation systems and sustaining crop production in the region.

Additionally, the combined outflow of the Chu, Talas, and Assa rivers to Kazakhstan is estimated at 2.03 km^3 per year. This water flow is significant for Kazakhstan, supporting agricultural activities and ensuring the availability of water resources for the local population.

These outflows of water from Kyrgyzstan to its neighboring countries highlight the interconnectedness of water resources in the region. Collaborative efforts and agreements between these countries are essential to ensure equitable sharing and sustainable management of water resources. Furthermore, effective water resource management practices, including conservation, infrastructure development, and water-sharing agreements, can contribute to the overall socio-economic development and well-being of the region. The sustainable utilization of water resources will not only ensure the availability of water for various sectors, but also foster cooperation and stability among neighboring countries.

Kyrgyzstan is one of the most water-rich countries in Central Asia and continental Eurasia (Table 2). The country ranks second in Central Asia, after Tajikistan, in terms of specific indicators of water resources per capita (FAO, 2012). This reflects Kyrgyzstan's substantial available renewable water resources, which place it among the most freshwater-abundant nations in the broader Eurasian landmass. Kyrgyzstan's favourable water endowment is a critical asset, particularly given the increasing water stress faced by many countries in this region as a result of population growth, economic development, and climate change impacts. The country's abundant freshwater resources play a vital role in supporting Kyrgyzstan's economy, society, and ecosystems, and highlight its strategic importance within the water-scarce environment of Central Asia.

Table 2. Available renewable water in Central Asia

No	Country	Available renewable water per capita per year, m^3
1	Kyrgyzstan	8,300
2	Tajikistan	7,200
3	Kazakhstan	3,700
4	China	2,100
5	Uzbekistan	500
6	Turkmenistan	248

The systematic study of the hydrogeological conditions of Kyrgyzstan began in 1951 with the creation of the Kyrgyz complex hydrogeological expedition. This expedition was responsible for consolidating all hydrogeological and engineering-geological works within the country. As a result of the planned work undertaken by the expedition, the territory of the Republic was completely covered by 1:500000 surveys, and almost entirely by 1:200000 and 1:500000 surveys. Additionally, approximately 25,000 exploration and production water wells were drilled.

Building upon the findings of earlier work and the ongoing efforts, as of January 1, 2020, the exploitable reserves of fresh groundwater in the Kyrgyz Republic have been explored, assessed, and accounted for by the State Balance at 117 deposits. Of these, 75 deposits are located in the northern regions, and 42 are in the southern regions. The total approved and accounted for by the State Water Balance reserves of fresh groundwater in the Kyrgyz Republic for all categories sum up to 25.4x10^6 m^3/day, including 3.1 x 10^6 *m^3/day* in the A category, 3.6 x 10^6 *m^3/day* in the B category, 6.1 10^6 million *m^3/day* in the C1 category, and 12.6 x 10^6 *m^3/day* in the C2 category. The projected operational reserves of fresh groundwater in the hydrogeological basins of the Republic are estimated to be around 30.4 x 10^6 *m^3/day*.

Kyrgyzstan has significant groundwater resources, with approved reserves amounting to 105,452 x 10^6 *m^3/day*. These operated groundwater deposits are utilized for a variety of purposes, including drinking, domestic, industrial, and irrigation uses. However, the level of utilization of these groundwater reserves is relatively low, ranging between 20-30% of the approved reserves (National Water Strategy of the Kyrgyz Republic until 2040, 2023).

The higher levels of groundwater use are observed in the more economically developed regions of the country, such as Bishkek, Chui, Issyk-Kul, Osh, and Talas oblasts. In total, around 15,000 groundwater extraction wells have been drilled across Kyrgyzstan, although the actual number of wells currently in use is unknown.

The monitoring and management of groundwater resources in Kyrgyzstan is overseen by two hydrogeological expeditions, one in the northern and one in the southern parts of the country. These expeditions are responsible for monitoring groundwater reserves, issuing licenses for groundwater use, and overseeing a limited number of specialized enterprises that have the right to drill and operate groundwater extraction wells.

The country is one of the richest countries in Central Asia in terms of hydromineral resources. The diversity of these resources, in terms of mineral composition, temperature regime, conditions of formation, and water manifestation, is exceptionally high, leading to a wide range of potential applications. However, the total number of occurrences and deposits of mineral waters is not precisely known, as the systematization, inventory, and electronic cataloguing of wells and springs are still ongoing processes.

As of January 1, 2020, 39 deposits of mineral and thermal waters have been included in the State Register of Mineral and Thermal Waters, with the exploitation and use of these resources being carried out through the withdrawal and use of groundwater from wells. The total operational reserves of hydromineral resources approved by the State Commission for Reserves and entered in the State Register amount to approximately 43,000 m^3/day. It is important to note that the deposits of mineral and thermal waters in the springs within the areas of their pinch-out, both in the Northern region and in the Kyrgyz Republic as a whole, are not yet accounted for by the authorities and are not included in the State Balance.

This relatively low level of groundwater utilization, despite the country's significant reserves, suggests potential for further development and management of these important water resources to support Kyrgyzstan's various economic and social needs, particularly in the more water-stressed regions of the country.

1.2. Water abstraction

Kyrgyzstan is endowed with substantial water resources, with an average annual surface water runoff of 48.6 x 10^6 m^3/day. However, the country only withdraws around 7 - 8 x 10^9 m^3/day xof this surface water for its own economic needs, with the vast majority (95%) used for irrigated agriculture. Interestingly, less than 1% of this surface water for irrigation is sourced from the main irrigation canals of Kazakhstan, Uzbekistan, and Tajikistan.

Groundwater resources have become an important source for Kyrgyzstan, supplying drinking and municipal water. Groundwater allocation has ranged from 0.2 to 0.3 x 10^9 m^3 per year over the past 3-6 years. When considering both surface and groundwater abstraction, the water use allocation is heavily skewed towards agriculture. Industrial water use makes up 4%, while population use constitutes 3% of the total water abstracted. Notably, a significant amount of abstracted water, between 2 to 3 x 10^9 m^3 annually, is lost through various processes.

Kyrgyzstan's water resources are utilized across several key sectors, with the allocations varying in quantitative terms. On average, from 2010 to 2020, the main types of water use were as follows: Hydropower –134 x 10^9 m^3; Irrigation and other agricultural use – 4.7 x 10^9 m^3; Industrial use –0.2 x 10^9 m^3 ; Population – 0.17 x 10^9 m^3 . This breakdown highlights the dominant role of hydropower in Kyrgyzstan's water usage, accounting for the largest share of the country's water withdrawal and consumption. Agriculture, the backbone of Kyrgyzstan's economy, is the second-largest user, followed by significantly lower allocations for industrial and population needs. The existing water withdrawal and use practices in Kyrgyzstan are structured around these established relationships and end-use patterns.

The inherent features of flow regulation and water use for hydropower generation are fundamentally at odds with the requirements of water use for irrigation purposes in Kyrgyzstan. Hydropower, owing to its practical non-substitutability, is required to be produced year-round, while energy consumption increases significantly during the winter months. In contrast, for irrigation needs, water should be stored in the winter and released in the summer.

Table 3. Water abstraction and use by the sectors

Name of indicator (10^6 m^3)	2019	2020	2021	2022	2023
Water intake from water sources	8,068.7	8,017.9	7,999.5	8,741.9	8,872.5
From groundwater	254.8	249.8	252.9	258.4	271.0
Water consumption	5,211.1	5,237.5	5,310.0	5,844.0	6,028.0
Industrial use	84.3	82.5	80.2	79.1	67.6
Agriculture and irrigation use	4,920.7	4,942.0	4,986.9	5,515.6	5,697.0
Wastewater	99.3	123.4	133.1	132.2	132.2
Treated water discharge	94.3	118.4	129.1	128.2	128.2
Non-treated water discharge	1.9	1.9	1.7	1.7	1.7

Source: Water Resources Service of the Kyrgyz Republic, 2024

The Naryn River, with its cascade of hydroelectric power plants, accounts for 90% of the country's electricity generation. However, less than 5% of the river's water resources are utilized for domestic needs. The Naryn River's water resources serve as the primary reserve for energy resource exchanges with downstream countries during periods of low water availability and hydropower generation shortages, helping to meet Kyrgyzstan's electricity demands.

The original purpose behind the construction of the Naryn Hydropower plant cascade was to store water in the winter and release it in the summer to support water users in Uzbekistan and Kazakhstan, in return for receiving electricity and other energy resources during the winter. The cascade of hydropower plants on the Naryn River generates up to 1.3 GW of electricity annually, predominantly for domestic consumption. During this electricity generation process, up to 12x 10^9 m^3 of water is discharged per year, considering the entire cascade of hydropower facilities. This discharge is carried out year-round, with a notable intensification during the winter months.

This inherent tension between the operational requirements of hydropower and the needs of the agricultural sector highlights the complex water management challenges faced by Kyrgyzstan, as it seeks to balance its energy security with the water demands of its irrigation-dependent economy.

1.3. Agricultural water use

The Kyrgyz Republic has 12.8 x 10^6 ha. of arable land, of which 9 x 10^6ha. are pastures, 0.2 x 10^6 ha. are hayfields,1.4 x 10^6 ha. are total sown areas, including 1,077 x 10^6ha. of irrigated land. Table 4 demonstrates the structure of the agricultural lands in the country (Table 4). Kyrgyzstan is among the countries that have limited arable land for agricultural production and limited potential to increase it. Arable lands make up only 11% of the total agricultural land and 6 % of the total land of the country. In addition to the current trend of growing transformation more than 3%, worsening of 35% arable land, degradation of pastures 80% have led reduction of the their productivity which create risks of sustainable supply of population with food.

Table 4. Area of agricultural land use in the Kyrgyz Republic, 2021

Total, ha	Including, ha				
	Arable land	Perennial plantations	Deposits	Hayfields	Pastures
10,606,100	1,287,300	76,700	34,700	20,3700	9,003,700

Source: National Statistical Committee of the Kyrgyz Republic (2022). http://www.stat.kg

Geographically, arable lands are located in the arid areas and water resources are unevenly distributed across the country. This requires the installation of a permanent irrigation system, given the mountainous landscape and the high cost of construction, maintenance of reservoirs and inter-farm irrigation systems, which creates a constant problem of financing and increases costs (Parpieva et al., 2023).

Kyrgyzstan has a significant agricultural sector that relies heavily on irrigation. The average around 4.7 x 10^9 m^3 of water is supplied per year for the irrigation of the agricultural lands (Water Resources Service of the Ministry of Agriculture of Kyrgyz Republic, 2022). In fact, more than 90% of the country's abstracted surface water is used in the agricultural sector. The yield of the main cultivated crops has shown a slight increase in recent years (National Statistical Committee of the Kyrgyz Republic, 2024), although, there is potential for increasing yields if precision farming is applied (Table 5).

Table 5. Main cultivated crop yields

Crop name	2019	2020	2021	2022	2023
			Crop yield, c/ha		
Grains	32.1	32.3	22.9	32.2	27.5
Wheat	25.1	25.5	14.5	25.4	19.1
Cotton (fabric)	32.8	33.4	34.8	35.4	36
Sugar-beet	514.8	533.9	358.3	518.1	472.9
Tobacco	24.4	26.5	25.3	26	27.8
Potatoes	171.3	171.8	170.4	170.2	175.9
Vegetables	198.7	200.1	193.3	197.4	206.9
Melons	220.6	222.8	203.9	210.9	228.1
Fruits and berries	52.9	52.3	50.2	53.8	54.4

Agriculture plays a crucial role in the Kyrgyz Republic's economy, contributing 13-15% of the country's GDP and employing around one-fourth of the population. Volume of agricultural output in 2022 reached to 354.7 billion KGS. Irrigated agriculture is a major livelihood activity, with nearly 90% of irrigation water supplied by surface water sources through gravity flow (UNECE, 2015). Pumped irrigation water supply accounts for only about 10% of the total, varying between1- 17% in different regions. This heavy reliance on surface water sources makes the agricultural sector highly vulnerable to the impacts of climate change.

The Kyrgyz Republic's agricultural lands have a diverse fertility potential due to the country's climate. As of the beginning of 2019, the total area of agricultural lands accounted for 53.1% of the country's territory, a slight decrease of 0.1% compared to the beginning of 2012, when it was 53.2%.

The regions with the largest sown areas are Chui (34.5%), Issyk-Kul (15.1%), Osh (14.7%) and Jalal-Abad (12.8%). Regional Crop Specialization has been formulated in consideration of the soil- climatic condition of the regions, which have the following peculiarities of the cropping pattern:

Chui region: Dominant production of grain and forage crops, vegetables, and potatoes.

Issyk-Kul region: Predominantly grain, forage crops, and potato production on larger parts of the sown areas.

Osh region: Sown areas primarily occupied by grain, forage crops, cotton, vegetables, and potatoes.

Jalal-Abad and Batken regions: Significant portions of agricultural lands are used for growing wheat, corn, cotton, forage crops, vegetables, fruits, and berries.

While expanding the cultivation of crops like beans, it is crucial to ensure the preservation of soil fertility and the maintenance of proper phytosanitary conditions in

Kyrgyzstan's agricultural lands. This balanced approach should involve the concurrent expansion of perennial grass and cereal crop cultivation. More than 65% of the arable lands in the Kyrgyz Republic are concentrated in the southern regions and the Chui oblast.

In terms of the overall crop cultivation structure in the country, the largest shares are occupied by cereals (553,400 ha.), forage crops (370,100 ha.), potatoes (84,400 ha.) and legumes (61,600 ha.).

The intensity of agricultural land use in Kyrgyzstan is reflected in the yields of the main crop types.

This regional specialization reflects the diverse agro-climatic conditions within Kyrgyzstan, which allows for the cultivation of a wide range of agricultural crops. The variations in crop production patterns across the regions highlight the need for tailored agricultural development strategies, and the efficient use of the country's arable land resources. One of the most important and problematic issues in Kyrgyzstan's grain farming sector is seed production. The varietal and sowing qualities of seeds in many farms do not fully meet the necessary requirements, the pace of introducing new high-yielding varieties remains relatively low, and the efficiency of producing quality varietal seeds with high sowing properties is insufficient.

Climate change is posing significant risks to the water resources in Kyrgyz Republic. Temperatures have increased by an average of 0.1°C per decade over the past 80 years, leading to the intensification and expansion of drought-related land degradation, which can severely affect labor productivity. Additionally, the loss of hydropower capacity due to climate variability may lead to increased reliance on fossil fuels, resulting in higher greenhouse gas emissions and further exacerbating the country's climate change challenges. The impacts of climate change on the Kyrgyz Republic's water resources are multifaceted. Flood and drought risks are expected to increase, with the annual probability of severe drought more than doubling from 14% in 2020-2039 to 31% in 2040-2059. This increase in drought frequency and intensity is expected to lead to a higher demand for irrigation, causing water deficits and potential yield declines in the agricultural sector.

1.4. Water supply and sanitation

The provision and operation of drinking water supply systems in Kyrgyzstan is primarily the responsibility of local authorities, rather than at the national level. According to the available information, there are a total of 1,891 settlements in the country, of which 1,805 are villages. The state of the drinking water infrastructure in these rural areas is concerning. In 267 villages, the drinking water supply system was built before 1960 and is now in a dilapidated condition. An even larger number of villages, 595, had their water systems installed before 1990 and are also in an emergency, outdated state. Furthermore, 390 villages do not have a drinking water supply system at all.

The collapse of the Soviet Union led to a decrease in water demand in Kyrgyzstan. However, based on various forecasts and considering national socio-economic development, the restoration of water consumption in the Chu River basin to 1,990 levels is expected in the coming years. The Bishkek Water Company, which serves the capital city, draws approximately 115 x 10^6 m^3/year for drinking water purposes. According to estimations, 25% of this water is lost through leakages and 8.25% is used for the company's own operations. It is estimated that there are around 960,000 water users, representing 80% of the city's population. The average water consumption in Bishkek is estimated to be 10^6 liters per capita per day, which seems relatively low. However, this consumption varies widely due to significant discrepancies in living conditions and access to water supply facilities. Some households have good access to water, while others do not. The actual water consumption is difficult to determine, as there is almost no water metering in place, and water audit statements are inadequate. Where meter readings are available, the average consumption is 210 liters per capita per day, but these readings are of limited relevance as they are from a small number of more affluent households and areas. The population served by the water system is expected to grow from 960,000 today to 1,300,000 in upcoming years.

This lack of access to clean, reliable drinking water is a significant challenge for the rural population of Kyrgyzstan. Estimates suggest that around 40% of the rural population in the country is not provided with drinking water in proper condition. The reasons for this widespread lack of adequate drinking water infrastructure in rural Kyrgyzstan are multifaceted. One of the primary factors is the significant underinvestment in water supply systems, particularly in remote and sparsely populated areas, over the past few decades.

Additionally, the decentralization of water supply responsibilities to local authorities has not always been accompanied by the necessary financial and technical resources to effectively manage and maintain the systems. Many local governments in Kyrgyzstan struggle with limited budgets, technical expertise, and institutional capacity to address the pressing issues in their water infrastructure. The consequences of this situation are far-reaching. Without access to clean drinking water, rural communities face increased health risks, including the spread of waterborne diseases. The lack of reliable water supply also hinders economic development and agricultural productivity, as water is essential for irrigation and livestock watering.

To address this challenge, the Kyrgyz government and international development partners have initiated various programs and projects aimed at rehabilitating and upgrading the drinking water infrastructure in rural areas. These efforts include the construction of new water supply systems, the renovation of outdated infrastructure, and the implementation of community-based management models. However, the scale of the problem is substantial, and progress has been slow. Significant additional investments, both from the government and international donors, are needed to ensure that all rural residents in Kyrgyzstan have access to safe and reliable drinking water.

The issue of water supply in rural Kyrgyzstan is further complicated by the impact of climate change, which is leading to changes in precipitation patterns and the availability of water resources. Adapting the water infrastructure to these new climatic conditions will require comprehensive planning and integrated water resources management approaches.

The water supply situation in rural Kyrgyzstan has been managed primarily through Community Drinking Water User Associations (CDWUAs) in recent years. In 2017, there were 742 such CDWUAs operating in the country, responsible for managing the water supply systems at the level of local rural communities. However, these CDWUAs have faced significant challenges in operating sustainably. As a result, the government is now in the process of reorganizing the rural water supply management, either by creating district-level enterprises or grouping settlements together to improve the efficiency and viability of the systems.

In urban areas, the water service providers are municipal enterprises known as Vodokanals. These urban water service providers, just like their rural counterparts, are facing financial difficulties due to low water tariffs that do not cover their basic operational costs. To address the broader water supply challenges in the country, the Kyrgyz government has developed a state program for the development of drinking water supply and wastewater disposal until 2026. This program envisages the construction of new water supply facilities, with the subsequent transfer of their management to local operators.

In 2017, the total volume of water released through the water pipeline network in Kyrgyzstan reached 320.75 x 10^6 m^3, from which 187.74 x 10^6 m^3 (58.5%) were supplied to the urban population and 133.01 x 10^6 m^3 (41.5%) were allocated to rural areas. However, the water usage for household and drinking needs amounted to only 157 x 10^6 m^3, indicating significant losses and unaccounted-for water consumption. The losses related to leakages and unaccounted water consumption, reached 67.3 million cubic meters. To address these challenges, it is necessary to attract investments in the water supply and wastewater disposal sectors. This includes the construction of new facilities as well as the reconstruction of existing infrastructure.

The provision and operation of drinking water infrastructure in Kyrgyzstan is the responsibility of local authorities. Around 40% of the rural population in the country lacks access to clean drinking water (National Statistical Committee of the Kyrgyz Republic, 2022). To address this issue, a network of community-based water user associations were established, managing the water supply systems at the local level. However, these community-level water associations have faced financial sustainability challenges due to low water tariffs that do not cover their operational costs. As a result, the government is now in the process of reorganizing the rural water supply management, either by creating district-level enterprises or grouping settlements together to improve the efficiency and viability of the systems.

In urban areas, municipal water enterprises are responsible for providing water services, but they too are struggling with financial difficulties due to low tariffs. To address the country's water supply challenges, the government has developed a state program aimed at constructing new water facilities and transferring their management to local operators by 2026 (Government of the Kyrgyz Republic, 2020).

The State Agency for Architecture, Construction and Housing and Communal Services is the responsible government body for attracting investments to construct new water supply and wastewater treatment facilities and rehabilitate existing ones. The centralized wastewater treatment system in Kyrgyzstan remains highly unsatisfactory, with only 28% of the population connected to such systems. Most treatment plants require rehabilitation or reconstruction, and small towns and district centers often lack any wastewater treatment facilities at all. This has led to the urgent issue of groundwater pollution due to improperly constructed septic systems.

Kyrgyzstan faces significant public health challenges related to water-borne diseases. Every year, more than 30,000 cases of acute intestinal infections are recorded in the country. The most common water-related intestinal infections include acute intestinal infections, viral hepatitis A, and typhoid fever. Of the total number of cases, 80% are children under the age of 14. The prevalence of these water-borne diseases highlights the critical need to improve access to safe and clean drinking water, as well as to strengthen wastewater treatment and sanitation infrastructure across Kyrgyzstan. The disproportionate impact on children underscores the vulnerability of this population group and the long-term implications for public health and societal well-being.

Addressing the root causes of these water-related illnesses, through investments in water supply, sanitation, and hygiene, should be a high priority for the Kyrgyz government and its development partners. Improving the quality and accessibility of water resources, while also promoting better hygiene practices, can help reduce the burden of these preventable diseases and safeguard the health of Kyrgyzstan's population, particularly its youngest and most vulnerable members.

CHAPTER 2. WATER SECTOR INSTITUTIONAL FRAMEWORK

2.1. Existing legal framework

In the recently ratified Constitution on May 5, 2021, article 16 has incorporated a significant principle that establishes the State's exclusive ownership over water, as well as land, its subsoil, air, forests, pastures, flora and fauna, and other natural resources (Constitution of the Kyrgyz Republic, 2021).

According to the provisions outlined in the Constitution, the President of the Kyrgyz Republic assumes the role of the constitutional guarantor, and serving as the country's representative on the international stage, holds the authority to sign laws and treaties. The Chairperson of the Cabinet of Ministers (CM) reports directly to the President, ensuring close communication and collaboration. The President represents the country at the Forum of Heads of State of the International Fund for Saving the Aral Sea (IFAS), showcasing their involvement in regional and international water resource management initiatives. The Parliament of the Kyrgyz Republic holds the responsibility of adopting laws, ratifying and denouncing international treaties, and approving the state budget.

This legislative body plays a critical role in shaping the legal framework and policies of the country.

Recognizing the importance of water and land resources, the National Council for Water and Land Resources (NCWLR) was established through a Presidential Decree on 24 November, 2021. Chaired by the President, the NCWLR includes the Chairperson of the Cabinet of Ministers and the Minister of Natural Resources, Environment and Technical Supervision as Vice-Chairpersons. The primary objective of this council is to enforce and implement the Water and Land Codes, among other assigned tasks. This highlights the government's commitment to ensuring effective management and protection of these valuable resources.

The Water Code (WC) of the Kyrgyz Republic was adopted in 2005 and has undergone several amendments over time (Government of Kyrgyzstan, 2005). While certain modifications have been made, the WC retains a number of key principles and provisions that remain unchanged. The primary objective of the Water Code was to establish a comprehensive legal framework for water-related matters, encompassing the use and protection of water resources. Its overarching aim is to ensure a sustainable water supply to the population while facilitating water withdrawal and utilization by various sectors of the economy. By consolidating provisions scattered across multiple legal acts, the Water Code successfully unified the regulatory landscape into a cohesive law.

The fundamentals of domestic and foreign water policy of Kyrgyzstan as a framework are stated in the Water Code of the Kyrgyz Republic. This ideology complies with the key principles of Integrated Water Resources Management worked out by the world community. The key water-related legal acts of Kyrgyzstan include the law "on Water" (1994), law "on Drinking Water" (1999). The environmental laws are the laws "On environment" (1999) and the laws on "general technical regulation on provision of environmental safety" (2009). The laws regulating complex sanitary-epidemiologic requirements are, the laws "on health protection of citizens of the Kyrgyz Republic" (2005), Law "On public health" (2009), and the law "on protection of consumers rights" (1997). The laws regulating procedures related to quality of water resources as well as certification of entities performing this activity are the Law "on environmental expertise" (1999) and the law "on the basis of technical regulation in the Kyrgyz Republic" (2004).

The laws regulating the quality of drinking water are, "technical regulations" and "on safe drinking water" (2012) (UNECE, 2013).

The laws on structure of the Government of the Kyrgyz Republic, local administration and local self-governance, land, subsoil, energy, emergencies, public associations of water users as well as other laws related directly or indirectly to regulation of use and protection of water resources and public health.

National Water Strategy until 2040 was approved in February 2023 by the Kyrgyz Republic President Order from 10.02.2023. Designed to tackle persistent water crises, the document outlines specific measures to improve water-sector governance, introduce a unified information system on water resources, and encourage resource-saving behaviour.

The scope of the National Water Strategy (NWS) until 2040 is to create a sustainable water resources management system in the Kyrgyz Republic for the benefit of present and future generations. To achieve this goal, measures will be implemented in the following priority areas: (a) protection of water resources from depletion and pollution; (b) rational use of water resources; and (c) reform of the water resources management system.

Task 1. Protection of water bodies: (a) preservation of waterbodies in a condition that ensures their environmental sustainability; (b) improving the accounting and control of water use, monitoring the state of waterbodies and controlling environmental pollution. *Task 2.* Improving state water registration: (a) improving the state accounting of waterbodies and the water resources concentrated in them, which constitute the state water fund, is the basis for increasing the efficiency of water use and protection thereof; (b) measurement of water quantity and water quality, including monitoring of waterbodies; (c) strengthening of state control over compliance with water legislation; (d) keeping State water register; and (e) recording and registration of water users based on the issuance of permits/licenses for water use.

Task 3. Ensuring safe and high-quality water supply, sanitation and wastewater disposal: (a) use of low water consumption technologies in industry; (b) division of water supply into drinking and domestic in the housing and communal services sector; and (c) introduction of mandatory instrumental metering of extracted groundwater and withdrawn surface water by water users.

Implementation of the strategy will allow the creation of a sustainable water resources management system at the national level to preserve the natural potential for the benefit of the present and the future generations (Government of the Kyrgyz Republic,2023).

2.2. Current institutional structure of water governance

Indicators for the implementation of the NWS for 2023-2025 were adopted by the government (Government of the Kyrgyz Republic, 2023), which defines realization of the prioritized tasks in short term period, which includes the key implementation indicators (Table 6).

Table 6. Indicators of the implementation of the NWS for 2023-2025

No	***Indicators of implementation***	***Data***
I	Harmonization of the regulatory and legal framework	
1.1	Separation of the functions of state policy on the protection and rational use of water resources from water management regulation	2023
1.2	Restoration of the permitting system for water use	2023
1.3	Improvement of regulatory legal acts on the sustainable functioning of the monitoring system and state accounting of waters	2023

Continuation of Table 6

1.4	Implementation of the State Water Cadastre system 2025	2025
1.5	Improvement of the system of state statistical reporting on water issues	2024
II	Implementation of basin management	
2.1	Approval of the boundaries of the main basins 2023	2023
2.2	Creation of basin councils in all main basins	2023
2.3	Implementation of the functions of the basin administrator in subordinate units of the authorized body	2023
2.4	Creation in departments of the divisions for maintaining the State Water Cadastre	2023
2.5	Approval of basin plans 2024	2024
2.6	Holding meetings of the National Council annually	2023-25
III	Digital transformation of the Unified Information	
3.1	Creation of an analytical unit for maintaining the Unified Information System on Water	2023
3.2	Automation and digitalization of the register of water bodies	2023
3.3	Automation and digitalization of the licensing and permitting system	2025
3.4	Automation and digitalization of the register of water users Sustainable economic mechanisms for water resources management that stimulate rational water use	2024
IV	Sustainable economic mechanisms for water resources management that stimulate rational water use	
4.1	Start of collection for the use of surface water resources for industrial purposes	2023
4.2	Improvement of the regulatory legal act on definition and collection of fees for the use of surface water resources in the Kyrgyz Republic	2023
4.3	Start functioning of the permitting system for the use of surface water resources	2023
4.4	Beginning of a phased transition to financing the Unified Information System on Water	2023

One of the important provisions within the WC is the establishment of a state water administration and basin management bodies, including basin administrations and basin councils. The State Water Administration plays a crucial role in facilitating effective coordination among relevant ministries and agencies involved in water resources management. Its mandate also includes optimizing investments and financial resources allocated to the water sector for enhanced efficiency. In terms of implementation, it was envisioned that the approval of the NWS for the period up to 2040 will accelerate to adopt to outline long-term measures for water resource management.

The implementation of the basin approach, as prescribed by the WC, is expected to contribute to the rational use of water resources, improvement of water quality and ecosystems, prevention of water conflicts, and the implementation of integrated water resources management (IWRM). An integral aspect of IWRM is stakeholder engagement in decision-making processes through the establishment of basin councils. The WC also emphasizes the practice of water use based on the permit system and recognizes the importance of water as a natural resource. By implementing a permit system and emphasizing water accounting, the WC aims to promote rational and economically viable water usage.

It is worth mentioning that the lack of full enforcement of key provisions within the WC often necessitates reference to the Water Law of 1994. The Water Law of 1994 laid the foundation for regulating the water sector, including the right to levy fees for water withdrawal and usage, as well as for managing wastewater and pollutant discharges within established limits.

There are several other legal acts that play a significant role in governing water relations. These acts include:

-*The Law on Water Users Association* (2002): This law provides the legal foundation for the establishment of Water Users Associations (WUAs) that bring together water users across the country. It also identifies the main water supply contractor for water distributors, which are the district offices of the State Water Management Service.

-*The Law on Interstate Use of Water Bodies, Water Resources, and Facilities* (2001): This law outlines the principles for joint water usage with neighboring countries and establishes mechanisms for compensating for the use of water bodies within the territory of Kyrgyzstan.

-*Multilateral and bilateral water treaties*: Kyrgyzstan has entered into several water-related treaties with neighboring countries. Notable examples include agreements on the Chu and Talas river basins with Kazakhstan (2000), the Syr Darya River basin with Kazakhstan and Uzbekistan (1998), and the interstate use of the Orto-Tokoi (Kasan-Sai) reservoir with Uzbekistan.

-*The principles of watershed and shares*: These principles were initially established by the USSR Ministry of Water Resources in 1984 and have been maintained by the Central Asian countries during negotiations on the Aral Sea Basin from 1994 to 2000.

In 2021, changes were made to the structure and composition of the government, aligning with previous constitutional changes that significantly altered the status of the government headed by the President. The President now holds direct responsibility for executing laws and implementing national development programs, policies, and strategies. As part of these changes, the responsibility for defining water policy was transferred to the Ministry of Water Resources, Agriculture and Processing Industry.

2.3. Functionality of the main agencies involved in the water sector governance

The Ministry of Water Resources, Agriculture and Processing Industry of the Kyrgyz Republic (the Ministry) is the authorized state executive body responsible for implementing the state policy in the field of water resources, including the water fund, drinking water supply and sanitation, land reclamation, irrigation and land reclamation infrastructure, the agro-industrial complex, including livestock, veterinary, fish farming (aquaculture), crop production, plant quarantine, agricultural lands (state fund of agricultural lands and pastures), food and processing industry.

The key points regarding the Ministry's role and responsibilities are:

- The Ministry is the authorized state executive body responsible for implementing the state policy in the field of water resources management.
- This includes the management of the water fund, drinking water supply and sanitation, land reclamation, irrigation and land reclamation infrastructure.
- The Ministry's scope also extends to the agro-industrial complex, including livestock, veterinary, fish farming, crop production, plant quarantine, and the food and processing industry.
- The Ministry ensures the uniformity in the application and observance of land and water legislation in Kyrgyzstan.
- It also exercises state supervision and control in the field of veterinary and phytosanitary safety, as well as compliance with land and water legislation of the Kyrgyz Republic.
- Additionally, the Ministry is responsible for green and organic agriculture, and adaptation and mitigation measures in agriculture in connection with climate change.

Given this broad mandate, the Ministry plays a central role in the legal framework and administration of water resources management in Kyrgyzstan, overseeing various aspects related to water resources, infrastructure, and the wider agricultural and industrial sectors.

Specifically, the legal framework for water resources management in Kyrgyzstan is mainly carried out by the Water Resources Agency of the Ministry of Water Resources, Agriculture and Processing Industry of the Kyrgyz Republic (the Agency) (Figure 2). The Agency is a subordinate division of the Ministry of Agriculture and Land Improvement of the Kyrgyz Republic, responsible for managing, monitoring, and regulating the state and use of water resources, irrigation and land improvement infrastructure, and carrying out executive, administrative, and coordinating functions related to the implementation of the single state water policy.

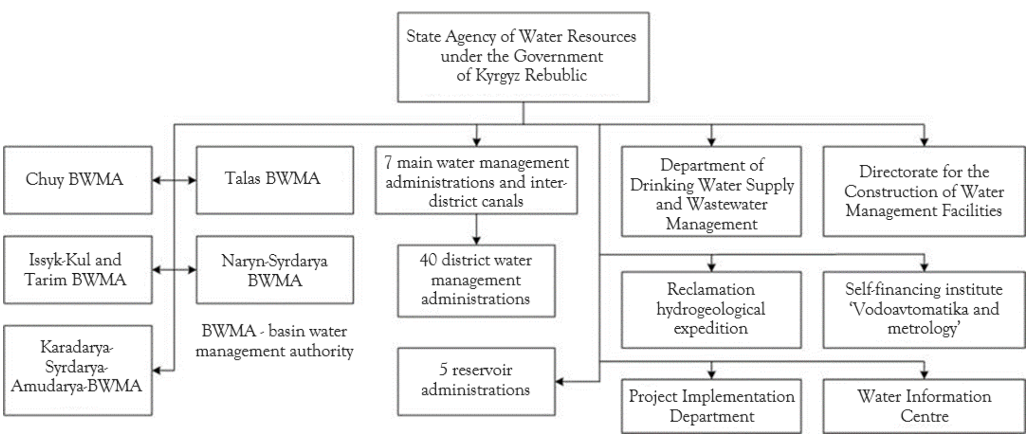


Figure 2. Structure of the Agency of Water Resources

The Agency is guided by the Constitution of the Kyrgyz Republic, relevant laws, and other enactments that have entered into force in accordance with international agreements to which Kyrgyzstan is a party. It is a legal entity with its own balance sheet, accounts, seal, and other attributes, and it operates within the principle of delimitation of regulatory, economic, administrative, and supervisory functions.

The objective of the Agency is to implement a single state policy in the field of rational use and protection of the water fund, manage water resources and water infrastructure facilities owned by the state, and ensure the comprehensive water needs of all water users. Its tasks include planning, organizing, and implementing measures for administrative, economic, and statutory regulation of water use; planning and implementing measures for the effective operation and protection of water infrastructure facilities and lands of the water fund; and integrated planning and regulation of water resource use based on river basin principles.

The Agency's functions encompass a wide range of responsibilities, including participating in the development of draft enactments, serving as the Secretariat of the National Water Council, developing plans for the integrated use and protection of water resources, and regulating procedures and tariffs for water supply services. It also coordinates with other administrative Agencies and local authorities in the development and review of national and regional strategies, programs, action plans, and business projects related to water resources, water infrastructure facilities, and water relations. The Agency represents the Kyrgyz Republic in international cooperation and ensures the implementation of interstate agreements and agreements to which Kyrgyzstan is a party, as well as planning and organizing the interstate distribution of water resources. It also has the authority to regulate the use of surface, groundwater, and recycled waters, issue opinions on the availability of water resources, and regulates the operation regimes for water bodies, water management schemes, and interstate property facilities. The Agency has the power to restrict or suspend the right of water use for legal entities and individuals in cases provided for by water legislation, and it regulates pricing for water management works and services. It develops and approves standard contracts for water supply and other works and services related to the economic aspects of water relations, and it issues, suspends, and recalls licenses for the construction of dams on rivers and water bodies.

In terms of coordination and control, the Agency coordinates the activities of river basin water councils and water user associations, coordinates the development of river basin plans for the use and protection of water resources, and ensures the supervision of their implementation. It also provides organization and administration of the permitting system for water use, maintains a single information system on the state and use of surface and groundwater resources, and prepares and submits materials on violations of water legislation to law enforcement agencies.

The Agency creates working commissions for carrying out inspections of individual structures and units, accepts buildings and structures for water management purposes, prior to the state acceptance commission, and develops and coordinates the implementation of measures to ensure the safety of dams and other water management structures. It also carries out state control over the provision of standard maintenance of water infrastructure facilities owned and managed by independent water users, as well as municipal property, and it maintains the state water cadaster under the section "Use of water" and the state land reclamation cadaster.

In addition to its regulatory and control functions, the Agency also provides direct service delivery, such as organizing and carrying out water intake, transportation, and supply of water resources to water users, as well as construction and installation, rehabilitation, repair, reclamation, and other works in the framework of state orders and on the basis of contracts with water users and other customers. It also organizes and carries out work related to the provision of a sustainable and safe state of irrigation infrastructure facilities, improvement of the irrigated land reclamation status, and improvement of the state and rational use of water fund lands allocated for irrigation and collector-drainage systems.

The Agency is entitled to make proposals on the improvement of legal, institutional, economic, technical, and other aspects of water relations that fall within its competence, and it can freely visit enterprises, institutions, organizations, protected areas, and other objects to carry out inspections of compliance with water legislation, draft acts, inspection reports, and issue instructions to eliminate identified violations. It can also request and receive information related to its scope from government bodies, local governments, organizations and enterprises, officials, and citizens of Kyrgyzstan, and it can accumulate financial funds in designated accounts for the collection of payment for the supply of irrigation water. The Agency is the administrator of budgetary and other means allocated to it for the purposes of management, regulation, rational use of water resources, as well as maintenance, operation, and development of irrigation and ameliorative structures under state ownership. It is headed by the Director-General, who is appointed and dismissed by the Prime Minister of the Kyrgyz Republic upon the recommendation of the Ministry of Water Resources, Agriculture and Processing Industry, and who represents the Agency in international organizations and foreign partners, bears personal responsibility for the exercise of the functions and powers entrusted to the Agency, and approves the functional duties of the Agency's employees, the structure, and staffing of the central office and subordinate organizations.

The remaining functions of water governance and management in the Kyrgyz Republic are distributed among various entities, each with specific responsibilities. The Ministry of Natural Resources, Environment, and Technical Supervision (MNRETS) not only defines water resources policy but also monitors the quality of surface waters affected by wastewater discharges. MNRETS inspects pollution sources and ensures compliance with regulations in the utilization and exploitation of water resources through its state agencies.

The State Water Service (SWS), under the Water Resources, Agriculture and Processing Industry, is responsible for surface water abstraction and its supply to water users, excluding drinking water and hydropower generation. SWS also play a crucial role in transboundary water allocation and technical coordination of water allocation agreements with neighboring countries. Additionally, SWS monitors the status and quality of agricultural drainage (secondary) waters.

Groundwater allocation for various purposes is managed by the State Enterprise "Kyrgyz Hydrogeological Expedition," which operates under the Ministry of Natural Resources, Environment, and Technical Supervision. This entity conducts inspections and grants licenses for groundwater use. Local authorities are responsible for providing drinking water from both surface and groundwater sources. They also undertake several tasks related to water resources, including approving the location, size, and regime of sanitary protection zones on rivers. Moreover, local authorities are involved in implementing regulations on water protection zones and overseeing the relationship between water suppliers and users at the local level.

*The State Agency for Architecture, Construction, and Housing and Communal Service*s, operating under the Cabinet of Ministers, takes charge of developing and implementing projects for the reconstruction and construction of drinking water supply and sanitation facilities. The State Enterprise, "Electric Stations," a part of the Ministry of Energy, operates state-owned hydroelectric power plants and coordinates the activities of private small hydroelectric power plants in the country (International Energy Agency, 2020). The State Hydrometeorology Service "KyrgyzHydromet," under the Ministry of Emergency Situations (MES), is responsible for hydrological monitoring and monitoring the quality of surface water. Although not directly responsible for water, the MES regularly deals with water bodies, such as rivers, and manages the impact of floods on both water bodies and infrastructure. The Department of State Sanitary and Epidemiological Surveillance (DSSES), operating under the Ministry of Health and Social Development (MHSD), is in charge of monitoring the quality of drinking water to ensure public health and safety.

On the water user side, *Water User Associations* (WUAs) play a vital role in managing on-farm irrigation networks and supplying water to end-users, primarily farmers. At the municipal level, municipal enterprises act as the main providers of water as a utility and often operate wastewater treatment plants. In rural areas and communities, district water utilities are responsible for the operation and maintenance of water supply and wastewater infrastructure. Considering that local communities consist of various water users and consumers, their engagement is crucial as important stakeholders. Raising awareness and shaping attitudes towards water management among local communities are essential goals.

CHAPTER 3. CLIMATE CHANGE AND WATER MANAGEMENT

3.1. Impact on agriculture

The Kyrgyz Republic is facing significant climate change challenges that are poised to have far-reaching impacts on its agriculture and water resources. Recent climate projections for the country paint a concerning picture for the coming decades.

The current warming trend is projected to continue unabated, with average temperatures expected to rise by 2^0C by 2060 and a staggering 4 - 5 ^0C by 2100 (World Bank, 2016). Notably, this warming will be more pronounced during the summer months, while winter temperatures are expected to change little. Compounding this warming trend, rainfall patterns are also forecast to shift dramatically, with precipitation projected to decline sharply during the summer season. This combination of higher temperatures and reduced summer rainfall will significantly heighten the risk of drought across the country. Conversely, winter precipitation is expected to increase, elevating the threat of floods and landslides. Additionally, rainfall variability is likely to grow, further destabilizing the country's climate. These profound changes in temperature and precipitation regimes will have wide-ranging impacts on the Kyrgyz Republic's agriculture and water resources.

The agricultural sector remains vital to community livelihoods and subsistence in the Kyrgyz Republic, despite its falling contribution to GDP. Key crops include wheat, corn, barley, potatoes, and cotton. However, the country has relied significantly on food imports since the turn of the 21^{st} century, operating an annual food trade deficit of around 150 million USD from 2008-2013. The agriculture sector has also suffered significant damage from natural hazards, with an average of 14 million USD in annual losses from 1991-2011, mostly due to drought and water shortages, especially for wheat production.

Climate change is expected to have both direct and indirect effects on crop growth and agricultural productivity in the Kyrgyz Republic. Direct effects include alterations to carbon dioxide availability, precipitation, and temperatures. Indirect effects include impacts on water resource availability and seasonality, soil organic matter transformation, soil erosion, changes in pest and disease profiles, the arrival of invasive species, and decline in arable areas due to desertification.

Overall, the outlook for crop production and agricultural livelihoods in the Kyrgyz Republic is mixed. Studies suggest a positive outlook in sub-humid (wetter) environments, but a negative outlook in arid environments. While higher CO_2 concentrations and warmer temperatures are expected to boost yields in key crops like wheat, the potential increase in the frequency of drought events and extreme heat could cancel out these gains. Some studies have suggested that cotton yields could reduce towards the end of the 21^{st} century, as well as becoming more volatile throughout. Demand for irrigation is likely to grow significantly, potentially leading to water deficits, especially to produce cotton and winter wheat. Farmers will require climate-smart infrastructure and technologies to maximize yields, but access to credit and necessary agricultural inputs represent major barriers to the adoption of such adaptation technologies. The projected effects on crop productivity vary considerably by region and crop type. While the productivity of staple crops like wheat, maize, and sugar beets is expected to decline, the cultivation of cotton, tobacco, rice, potatoes, and melons may see productivity gains. However, this divergence in trends will lead to major geographical shifts, with the Batken and Chui regions facing falling crop yields, while Naryn, Talas, Jalalabad, and Osh experience productivity increases.

The livestock industry may also be susceptible to climate risks, while also contributing to climate risks through poorly managed pastoral land. Recent studies show that climate changes have been negatively impacting the net primary productivity of grasslands across the majority (96%) of the country's land surface area, primarily linked to shifts in precipitation patterns (World Bank, 2016). Improved understanding of these dynamics and support for pastoral communities in building adaptive capacity will be essential. Pasture lands, which are critical for the country's livestock sector, are also projected to be affected by climate change, though not uniformly. Overall, climate models suggest a favorable impact on pasture productivity in most regions. However, the high-altitude pasture areas of the Tien-Shan, Ak-Say, and Alay valleys are expected to experience increased desertification due to the combined pressures of higher temperatures and reduced rainfall. A particularly concerning prospect is the projected decline in water availability for irrigation after 2025, as glacial melt diminishes. This, coupled with the forecast rise in summer temperatures, represents a major long-term risk for the Kyrgyz Republic's agricultural sector, which is heavily reliant on irrigation to sustain production.

The increased frequency and severity of droughts, floods, and other extreme weather events associated with climate change are likely to have significant impacts on agricultural production and the broader economy of the Kyrgyz Republic. The agriculture sector's exposure to production and price risks is increasing, and effective risk management strategies will be critical for the sector's long-term resilience and growth. Measures to strengthen risk mitigation must be integrated into sector development and investment programs, and the potential for risk transfer mechanisms, such as insurance, will need to be carefully explored and developed where feasible.

3.2. Water supply and sanitation

The long-term depletion of glaciers and more erratic precipitation patterns are likely to lead to a decrease in overall water supply in the Kyrgyz Republic (Reyer et al., 2017). This will exacerbate existing challenges in meeting water demands for agriculture, industry, and domestic use. As water scarcity increases, the government may need to raise water tariffs to incentivize conservation and fund investments in water infrastructure (World Bank, 2016). However, such measures could disproportionately burden the country's poor population, who may struggle to afford higher water prices (Rost et al., 2015).

Water resources in the Kyrgyz Republic face significant pressures, with studies documenting declines in stored water volumes from 2003-2013 (Deng & Chen, 2017). While human development activities such as the expansion of irrigation have been the primary drivers of water stress, the impacts of climate change are also substantial in addition to expansion of urban population.

If the amount of water drawn increases linearly with the expected population increase in capital city of Bishkek, this would mean an extra $40 \times 10^6\ m^3$ (up to $155 \times 10^6\ m^3$) would be needed to serve the population, if no efficiency improvements are made. Beyond this, the demand for water will continue to increase. The Kyrgyz government and water authorities must take proactive measures to protect and manage the surface and groundwater resources in the Chu River basin. This includes implementing preventive measures to address the growing water scarcity and ensure the sustainable use of water resources to meet the needs of the population. Given the challenges faced, it is crucial for the authorities to prioritize water management and conservation efforts to ensure a reliable and equitable water supply for the people of Kyrgyzstan in the years to come.

The mountainous regions of the Kyrgyz Republic, particularly the Tien Shan and Pamir ranges, have been experiencing rapid glacial melt in recent decades (Barandun et al., 2018). In the short to medium-term, this is likely to increase runoff from the mountains, potentially peaking around 2040 (Gan et al., 2015). However, beyond this point, the depletion of glaciers is expected to lead to severe water shortages before the end of the century, as the primary source of the country's water supply diminishes. Glaciers are calculated to supply up to 50% of the total runoff in small, glaciated catchments of Kyrgyzstan during summer months (Sadyrov et al., 2024). The combination of climate-induced changes in the water cycle, including shifts in the timing and intensity of precipitation and runoff, along with increased evapotranspiration, is projected to dramatically increase the probability of drought conditions in the country (Dixon & Wilby, 2019). This poses significant risks not only for the agricultural sector, but also for domestic and industrial water supply.

Pressures on water supply caused by climate change are a concern not only for the Kyrgyz Republic, but also for its neighboring countries, as the majority of Central Asia's fresh water originates from the mountains of the Kyrgyz Republic and Tajikistan (ADB, 2014). Careful management of key water infrastructure, such as the Toktogul reservoir, will be essential to minimize health impacts and loss and damage on communities across the region.

In addition to issues with water quantity, climate change will also impact water quality. One important water body, Lake Issyk-Kul, is home to endemic fish species and has historically underpinned significant economic activity, including tourism. While studies have largely attributed changes in the lake's water levels and quality to human development pressures, the potential impact of climate changes on the lake's health will require further research and monitoring (Alifujiang et al., 2017; Alymkulova et al., 2016; Alamanov and Mikkola, 2011).

3.3. Industrial and other users

Hydropower plays a significant role in Kyrgyzstan, a country abundant in hydroelectric resources, with approximately 90% of its electricity being generated from large-scale hydroelectric power stations along the Naryn River (Lemenkova, 2013). The Toktogul reservoir, controlled by upstream Kyrgyzstan, is crucial for hydropower generation, especially in winter for heating purposes (Abbink et al., 2009). The country faces challenges due to climate change, with studies indicating an increasing vulnerability of the country's agricultural systems to drought disasters (Li et al., 2021; Liang et al., 2021).

Despite this reliance on hydropower, the total energy production by hydropower plants has decreased in recent years. In 2018, the energy production from hydropower plants was 14.3 x 10^9 kWh, but this dropped to 11.9 x 10^9 kWh in 2022. As a result, Kyrgyzstan has been increasingly relying on imported electricity, with 16% of the total consumed power being imported in 2022. The primary factor contributing to the decline in hydropower generation is the impact of climate change (Reyer et al., 2017). Changing rainfall patterns, increasing temperatures, and droughts are expected to reduce the reliability and availability of water for hydropower generation in Kyrgyzstan. The area of glaciers in the country has decreased by 16% over the past 70 years, and it is predicted that small glaciers may completely melt by 2100 (Sorg et al., 2012).

Figure 3. Potential hydropower projects in Kyrgyzstan

Source: BneIntelliNews, 2024

In 2024, Kyrgyzstan is undertaking a comprehensive effort to rejuvenate its aging power infrastructure (Figure 3). This initiative goes beyond the high-profile 5 billion USD Kambarata-1 hydropower plant (Kambarata-1 HPP), and includes plans for a dozen smaller HPPs. These projects aim to double the country's installed generating capacity to 10 GW in the coming years, potentially reaching a collective output of 80 GW by 2027, as announced at the Kyrgyz Republic Energy Forum (KREF) in Vienna (Bne IntelliNews,2024). Currently, Kyrgyzstan's power output stands at 3.9 GW, with hydropower accounting for 80% of the mix. Despite being a mountainous country with over 45,000 kilometers of rivers, the nation has barely tapped into its vast hydropower potential, according to World Bank experts. They estimate the republic could increase its HPP generation output 25-fold. The Kambarata-1 HPP is expected to add 1.8 GW to the country's installed capacity upon completion. However, the World Bank has stated that Kyrgyzstan will need to reach 10GW of generation by 2030 to sustain its robust economic growth of 7-8% annually.

To achieve this goal, Kyrgyzstan plans to invest an additional 11 billion USD in a series of smaller energy projects as part of its National Energy Program till 2035. This will ensure power supply to the entire country. The government is also prioritizing the development of HPPs that can enable power exports to neighboring Uzbekistan and Kazakhstan, as well as feed into the 1.2 billion USD CASA-1000 regional transmission line. This line will export electricity from Central Asia to Pakistan and beyond. The World Bank approved the restart of the stalled CASA-1,000 initiative in February 2024.

The shrinking of glaciers leads to reduced water content in the rivers, which directly affects the water supply for hydropower plants. Moreover, the average yearly air temperature in Kyrgyzstan has increased by 2.39 ^{0}C from the beginning of the last century to 2021, further exacerbating the challenges posed by climate change (WB&ADB, 2021). The reliance on hydropower and the vulnerabilities posed by climate change have created a pressing need for Kyrgyzstan to diversify its energy mix and explore alternative energy sources. This could include the development of solar, wind, and other renewable energy projects to complement the existing hydropower infrastructure and ensure a more resilient and sustainable energy supply for the country.

Furthermore, rainfall-induced mudflows are also anticipated to intensify, especially in the southern oblasts (regions) of the country. There are approximately 5,000 zones susceptible to mudflows, with 3,500 of them located in the south. These mudflows can cause significant damage to agricultural infrastructure and disrupt water supply systems, further compounding the challenges faced by the agricultural sector. The irrigation infrastructure is also aging and in need of modernization. Much of the irrigation network was constructed during the Soviet era and has deteriorated over time, leading to significant water losses and inefficiencies. This, combined with the impacts of climate change, has reduced the reliability and availability of water for irrigation, affecting agricultural productivity and livelihoods.

To address these challenges, the Kyrgyz government has undertaken various initiatives to modernize the water sector and improve water management. The National Water Resources Management Project (NWRMP), supported by the World Bank, has focused on rehabilitating and upgrading irrigation and drainage (I&D) infrastructure, strengthening institutional capacities for integrated water resources management (IWRM), and promoting the use of water-efficient technologies.

Additionally, the government has been working to diversify the country's crop patterns and introduce more climate-resilient agricultural practices. This includes promoting the use of drought-tolerant crop varieties, improving soil management techniques, and enhancing on-farm water management practices to improve water-use efficiency. The country's vulnerability to climate change underscores the need for a comprehensive and integrated approach to water resources management. Investments in climate-resilient water infrastructure, the promotion of water-efficient agricultural practices, and the strengthening of institutional capacities for IWRM are crucial for ensuring the long-term sustainability and resilience of the agricultural sector.

3.4. Trends on depletion of water resources and recent policy arrangements

The Kyrgyz Republic has traditionally had sufficient water resources to sustain irrigated land demands, although since 1960 the high-altitude glaciers have decreased in size by approximately 20% (GFDRR, 2011). As of 2016, nearly all the irrigation systems in the country are managed across 481 Water Users' Associations (WUAs), which are non-governmental organizations that manage, operate, and maintain irrigation systems at a local level. However, during drought and dry seasons, inefficient and ineffective irrigation practices can lead to acute water scarcity in the country.

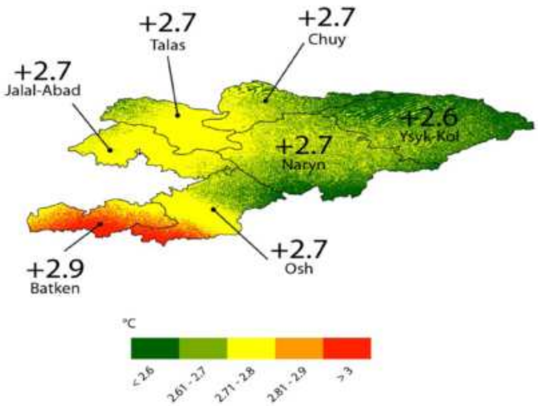


Figure 4: Projected changes in annual mean temperature of the Kyrgyz Republic by 2050

Source: World Bank, Climate Smart Agriculture profile, 2018.

Analysis of climate change parameters from 1960 to 2010 shows an accelerated increase in average annual temperatures over time, rising 2.4 ^{0}C on average during this period. Climate model projections suggest average temperatures are likely to continue increasing in all climate zones, by 2.7 ^{0}C by 2050 (Figure 4) and up to 3.1 ^{0}C by 2070. The country's average annual precipitation ranges from 300 to 600 mm/year and instrumental observations reveal a steady increasing trend for the period 1960-2010, with a slight reduction from 1990-2010. Precipitation projections indicate an average 6% and 7.5% increase in total annual precipitation by 2050 and 2070 (WB, 2018), respectively (Figure 5).

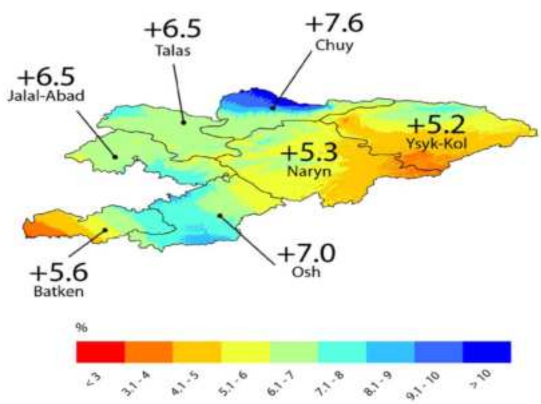


Figure 5: Projected trends in annual precipitation of the Kyrgyz Republic

The CMIP 5 climate projections from the Climate Change Knowledge Portal (CCKP) for the Kyrgyz Republic anticipate an increase in average annual temperatures under future climate scenarios. For the intermediate future period of 2040-2059 (reference period of 1986-2005), the 50th percentile projections show a temperature increase of 2^0*C* under the moderate RCP 4.5 emissions scenario, and up to a 2.5^0*C* increase under the business-as-usual RCP 8.5 scenario. Under the 90th percentile, the temperature increase is projected to be even higher, reaching up to 3.3 ^{0}*C* (RCP 4.5) and 4.1 ^{0}*C* (RCP 8.5).

More recent CMIP6 model projections for the period of 2021-2050 (reference period 1981-2010) indicate a temperature increase of 1.5 to 1.9 ^{0}*C*, depending on the emissions scenario, with the maximum increase expected in summer, reaching 1.7 to 2.2 ^{0}*C* (Kretova, 2020). While these CMIP6 projections cannot be directly compared to the CCKP results due to differences in the future and reference periods, they confirm the overall increasing trend in temperatures and suggest that the average annual temperature increase may underestimate the peak warming during the summer months, which could have stronger negative impacts on infrastructure and other sectors.

Kyrgyzstan's water resources are expected to face increasing pressure in the coming decades due to the combined effects of climate change, population growth, and economic development. Domestic water demand is predicted to grow, fueled by population expansion and rising living standards, particularly in urban centers. Industrial water use is also forecasted to increase as the country's economy and manufacturing sectors continue to develop (Strelkovskii, 2020).

Agricultural water demand, which accounts for the largest share of current water use, is expected to see a more modest increase by 2050 due to efficiency improvements and shifts in crop patterns. Climate change is likely to exacerbate water stress, with rising temperatures and changes in precipitation patterns, potentially reducing water availability, especially during the summer irrigation season.

Glacier and snow melt, which currently provide a significant portion of Kyrgyzstan's surface water resources, are projected to decrease in the coming decades because of global warming. Groundwater resources, crucial for domestic and agricultural use, may also face depletion due to increased extraction rates and reduced natural recharge.

CHAPTER 4. WATER TARIFFS AND INVESTMENTS

4.1. Investments into the water sector

The water sector in the region faces a significant financing shortfall, with the current average annual financing amounting to only around 168 million USD, while the estimated annual deficit is approximately 280 million USD (WB, 2022a). This insufficient funding is largely due to the capacity of state budgets, as well as the prevailing outdated practices in various water management activities that are primarily financed by the government focusing more on other sectors.

One of the key factors contributing to the financing gap is the inadequately low tariffs for irrigation and drinking water supply. These tariffs have not been adjusted to reflect the true costs of water delivery and management, resulting in a mismatch between revenue generation and the actual expenses required to maintain and upgrade the water infrastructure. Additionally, the charges for water used for production purposes have been regulated, and it was only recently, in October 2021, that the government took steps to increase these charges through a new resolution. Therefore, most of the investments in the water sector were made by international partners.

The World Bank project "Irrigation Rehabilitation" provided a 43.8 million USD loan (including a 37.2 million USD credit funds) with the project implementation period from September 1998 to December 2005 and May 2006. The project components included rural and institutional development and capacity building, institutional development for project implementation, rehabilitation of irrigation infrastructure, and restoration of operation and maintenance services.

The World Bank project "On-Farm Irrigation" was financed by the IDA at a cost of 29 million USD. The project aimed to rehabilitate on-farm irrigation and drainage infrastructure covering 121,000 ha. and to establish, develop, and strengthen Water User Associations (WUAs). The project was completed in 2008. Key project outcomes included the formation and development of viable WUAs to take over the maintenance and upkeep of on-farm irrigation infrastructure (allocated 6.3 million USD), and the physical rehabilitation of on-farm irrigation infrastructure to ensure reliable water supply to farmers on a project area of 160,000 ha. During the project realization, WUA support departments were established. Training courses were developed on WUA formation and development, financial management and administration, engineering, water use, monitoring and evaluation, and legal foundations of WUA activities. As a result, 396 officially registered WUAs were created, covering 580,000 ha. or 55% of the total irrigated area.

The Second On-Farm Irrigation Project (OFIP-2) was implemented from June 2007 to June 2013 with a budget of 20.6 million USD, including a 16 million USD, IDA grant and 4.6 million USD from the Government of Kyrgyzstan (OSCE, 2010). The project components is aimed to ensure WUAs can effectively and productively use their rehabilitated on-farm irrigation systems sustainably, with a focus on water resources and asset management aspects. It also financed the rehabilitation and modernization of irrigation and drainage systems covering around 51,000 hectares managed by 29 WUAs.

The "Water Management Improvement" project, financed by the World Bank, the Government of Japan, and the Government of Kyrgyzstan, was implemented from 2006 to 2011 with a 28.1 million USD grant funds. The project aimed to improve irrigation service delivery and water resources management to contribute to sustained productivity increases in irrigated agriculture, as well as to improve the management of national water resources for the benefit of water users and the country as a whole.

The "Agricultural Development in Chui Oblast" project, financed by the Asian Development Bank from 1999 to 2005 with a 36 million USD loan, rehabilitated the irrigation and drainage system on 50,000 hectares in the Chui Valley. The "Emergency Flood Mitigation" project, financed by the IDA from 1999 to 2005, protected settlements and river hydraulic structures from floods and rehabilitated four hydrological monitoring stations.

T*he "Water User Association Support Project" (WUASP)*, financed by USAID at a cost of 4.73 million USD was designed to develop the capacity and resources of WUAs to manage local irrigation systems. It provided grants to WUAs for infrastructure improvements, training in innovative management methods, business planning, accounting, and equitable water distribution, as well as public awareness campaigns on the benefits of WUAs and efficient water use.

The "Natural Resources Management Program in Central Asia," funded by USAID, provided technical assistance, training, and limited equipment to Central Asian countries to improve the management of water and energy resources. In Kyrgyzstan, it established a regional telemetry system, installed eight hydrological stations on major rivers, and six automated weather stations.

The "Integrated Water Resources Management in the Ferghana Valley" project, financed by the Swiss Agency for Development and Cooperation, aimed to introduce water-saving methods, improve agricultural productivity, create WUAs, and improve water allocation mechanisms in Kyrgyzstan, Tajikistan, and Uzbekistan. It also supported the automation of the Aravon-Akbuurin Canal in Osh Oblast.

The "Rural Advisory Service" project, financed by the Swiss Agency for Development and Cooperation from 1999 to 2006, aimed to improve living conditions in rural areas, reduce poverty, and promote rural development through education, information dissemination, and experience sharing to reduce costs and increase incomes.

The "Southern Agriculture Development" project, initiated in 2007 with a 15 million USD ADB loan, included the rehabilitation of irrigation and drainage systems of select WUAs in Osh, Batken, and Jalal-Abad Oblasts.

The "Water Management Improvement Project," financed by the World Bank, is a continuation of the "Irrigation Rehabilitation" project with new components. The 28.1 million USD project aims to improve irrigation service delivery and water resources management for sustainable productivity increases in irrigated agriculture, as well as to enhance the efficiency of national water resources management for the benefit of water users and the country.

The "Efficient Water Use" project, implemented by Helvetas Kyrgyzstan since 2009, aims to improve farmers' capacity to manage scarce water resources in agriculture optimally to enhance agricultural productivity, food security, and natural resource conservation.

Over the years, international development agencies and funds from the US, Switzerland, Japan, the UK, and Germany have made significant contributions to strengthening the technical and organizational capacity of Kyrgyzstan's water sector. Estimates suggest that external credit and donor assistance covered around 58% of the actual costs of operation, maintenance, and rehabilitation of the inter-farm irrigation and drainage network in Kyrgyzstan during 2000-2006.

Since 2006, there has been an increase in domestic financial investments for strengthening the technical base of the irrigation sector. For example, in 2006, 40 million soms were allocated from the Poverty Reduction Fund for the rehabilitation of irrigation infrastructure, including 21.8 million soms for the rehabilitation of collector-drainage systems. After gaining independence, Kyrgyzstan did not undertake the development of new irrigated lands and construction of new irrigation canals and structures as envisaged in the Soviet-era water sector development programs. In 2008, the Government of Kyrgyzstan allocated 330 million KGS to complete the construction and commissioning of 9 remaining projects from the Soviet-era program.

From *2018 to 2023, water supply and drainage projects* were implemented in several cities across Kyrgyzstan, including Bishkek, Osh, Jalal-Abad, Naryn, Kant, and Talas. In 2021, the main works on projects in Osh city (phase 2) and Batken city were completed, and preparations are underway to put these projects into operation. Ongoing construction works are taking place in 9 cities - Bishkek (phase 2), Kara-Suu, Kyzyl-Kiya, Cholpon-Ata, Balykchy, Toktogul, Uzgen, Mailuu-Suu, and Tokmok - during the period of 2021-2023. Projects in Nookat and Kerben cities were ratified by the Kyrgyz parliament in 2021, and internal procedures are underway for signing sub-grant and sub-loan agreements.

Through the EBRD, *additional projects have been approved in 7 cities* - Tash-Kumyr, Kok-Jangak, Kadamjai, Aidarken, Kemin, Shopokov, and Kant (phase 2) - and feasibility studies are currently being developed. The Asian Development Bank (ADB) has provided 32.9 million USD million to cover 43 villages in Naryn province, with design and estimate documentation under development and construction works planned for 2021-2026.

The ADB's "Wastewater management in Issyk-Kul" project worth $41.82 million aims to modernize and expand wastewater treatment systems in Balykchy and Karakol cities. Under the "Small support for multi-sectoral activities - Small expenditure financing facility for the Kyrgyz Republic (SEFF)" project worth $10 million, chlorine neutralization equipment was installed and put into operation at the Osh dam water treatment plant.

The budgets of territorial water management organizations previously lacked budget lines for the maintenance of local WUA support departments, as their staff was funded by World Bank project investments. However, since mid-2008, the Government of Kyrgyzstan has transferred these units to state budget funding, and the cost structures of water management agencies should now adequately account for this decision.

Furthermore, the electricity tariffs in the region do not account for the costs associated with the accumulation and use of water for hydropower generation. This oversight in pricing mechanisms has led to a disconnect between the true value of water resources and the revenue generated from their utilization, further exacerbating the financing challenges faced by the water sector.

Access to clean drinking water is still a major challenge in Kyrgyzstan, with around 65% of rural settlements lacking proper access to safe drinking water. This is despite Kyrgyzstan being a country rich in water resources. The government launched the large-scale "Taza Suu" (Clean Water) project in the 2000s, with 69.5 million USD in funding from the Asian Development Bank and World Bank. However, the project faced corruption issues and mismanagement, leading to problems with the quality and sustainability of the water infrastructure built.

The government has a new program in place to ensure 95% of the urban population and 2 million rural residents have access to centralized safe drinking water by 2026. However, the program faces a funding gap of around 257.5 million USD that needs to be secured. The lack of accurate and comprehensive data on the water supply situation across Kyrgyzstan is a major challenge, making it difficult for the government to effectively plan and implement solutions.

Many rural communities have taken matters into their own hands, organizing community efforts (Ashar) to build their own water supply systems when government assistance is slow to arrive. However, the quality and long-term sustainability of these community-led efforts is uncertain. Maintaining and operating the existing water infrastructure is another major challenge, with many community-based water user associations struggling financially and technically. The government is now looking to create a state-owned enterprise to handle technical repairs and maintenance.

There is a new financing package of 100 million USD that has been secured by the World Bank to enhance water service provision in the Kyrgyz Republic (World Bank, 2022b). This investment is aimed at supporting the Climate Resilient Water Services Project. The funding for this project is provided through the International Development Association on highly concessional terms. The financing package consists of a grant and a credit. Half of the funding is allocated in the form of a grant, which does not require repayment. The other half is a credit with a 0.75% administrative fee. The repayments for the credit are spread out over 38 years, with a six-year grace period. The main objective of this investment is to enhance water service provision across multiple sectors in a sustainable and inclusive manner.

The implementation of economic instruments and charges for the use of water as a natural resource has been a long-standing issue in the Kyrgyz Republic. Despite the provisions in the Water Code, these measures have not been put into practice for many years. However, the National Water Council adopted a roadmap in 2019 to guide the implementation of the Water Code. According to this roadmap, the establishment of a properly functioning permit system could potentially generate significant revenue, estimated at up to 328 million USD annually, in the medium term. This would help address the funding gap that currently exists in the water sector.

4.2. Current water tariff regulation and policies

Irrigation water tariffs in Kyrgyzstan have historically been very low, often amounting to only a few dollars per hectare per year. These low tariffs were introduced during the Soviet era and have persisted since Kyrgyzstan’s independence in 1991. The low tariffs have led to several issues:

1. Inefficient water use: The low tariffs have provided little incentive for farmers to use water efficiently, leading to high levels of water waste and unsustainable irrigation practices. This has put significant strain on Kyrgyzstan’s limited water resources.

2. Lack of cost recovery: The low tariffs have not allowed for adequate cost recovery by the state-owned water management agencies responsible for operating and maintaining the irrigation infrastructure. This has resulted in underinvestment and deterioration of the irrigation system.

3. Inequitable distribution: The low, flat-rate tariffs have not differentiated between farmers based on factors like crop type, land size, or water use. This has led to an inequitable distribution of the irrigation water, with larger and more affluent farmers often using a disproportionate share of the available water.

To address these issues, the Kyrgyz government, with the support of the

OECD (OECD, 2019), has been working to reform the irrigation tariff system.

The key elements of the reform include:

1. Raising tariff levels: The tariffs are being gradually increased to better reflect the true cost of water delivery and incentivize more efficient water use.

2. Introducing volumetric pricing: The reform is transitioning from a flat-rate system to a volumetric pricing approach, where farmers pay based on the actual amount of water they consume.

3. Differentiating tariffs: The new tariff system incorporates differentiated rates based on factors such as crop type, land size, and water scarcity in the region, to promote more equitable water distribution.

4. Improving cost recovery: The higher and more differentiated tariffs are expected to improve the financial sustainability of the water management agencies, enabling them to better maintain and invest in the irrigation infrastructure.

The implementation of these reforms has faced some challenges, such as resistance from farmers and concerns about the potential impact on agricultural productivity and food security. However, the Kyrgyz government is working to address these concerns and ensure a gradual and socially acceptable transition to a more sustainable and efficient irrigation water management system (OECD, 2016).

The Kyrgyz farmers are willing to pay between 5-30% of their income for irrigation services, depending on the quality of those services (World Bank, personal communication). This suggests that most Kyrgyz farmers would be willing to pay more than they currently do for irrigation. Furthermore, studies have estimated the average economic value of water for irrigated agriculture in Kyrgyzstan to be around 13 KGS/m^3. Given this, the current irrigation tariff of 0.03 KGS/m^3 represents an insignificant proportion of the economic value gained from the water used for irrigation.

This indicates that there is potential to increase the irrigation tariff in line with the "beneficiary pays principle," where users pay a fair price that reflects the true economic value of the water they are using for their agricultural activities. Raising the tariff to better align with the economic value of the water could generate additional revenue to improve and sustain the irrigation infrastructure and services, ultimately benefiting the farmers.

One of the key factors contributing to the low economic value of water in the Kyrgyz Republic is the heavy reliance on irrigation, which accounts for 93% of the country's total water consumption. The pricing mechanism for irrigation water has remained unchanged since 1999, after the Law on Tariffs for Irrigation Water was adopted by the Jogorku Kenesh of Kyrgyzstan. According to this law, the price for contracting between irrigation water suppliers, known as DWMAs, and the main recipients of irrigation water, called WUAs, is set at 0.0006 USD (0.03 KGS), which was adjusted to 0.0004 USD/m^3 in

2021 based on the KGS/USD exchange rate. In turn, the WUAs enter into contracts with farmers for water supply at an average price of 0.0008 *USD/m*^{3} (0.07 KGS).

The extremely low tariffs for irrigation water supply services to farmers, which amount to an annual volume of 4.7 km^3, have led to significant underfunding and insufficient subsidies for this vital service. As a result, the irrigation water infrastructure in the Kyrgyz Republic has become worn out and outdated. The maintenance and repair of the irrigation canals, which have become clogged and are causing substantial water losses, have become a heavy burden for the state.

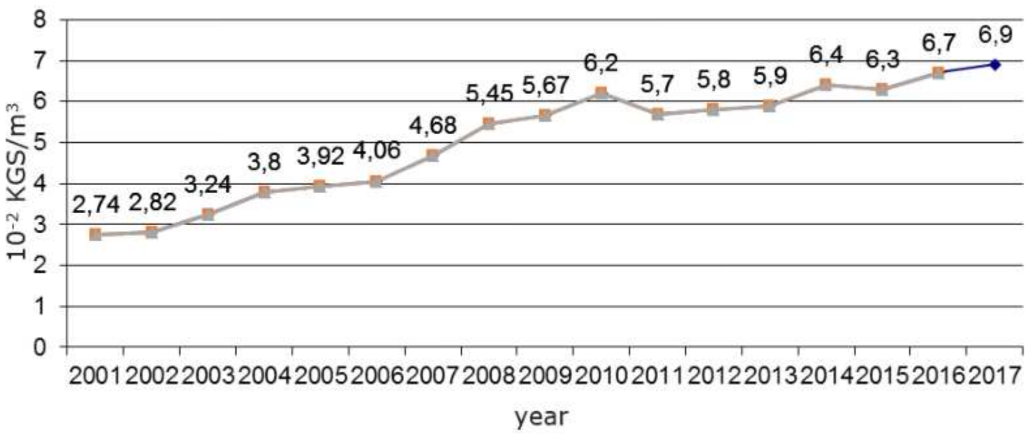


Figure 6. Tariffs for WUA irrigation water supply

Source: Water Resources Service of the Kyrgyz Republic, 2022

To address the funding gap and make necessary capital investments in the irrigation infrastructure, the government has primarily relied on credit resources and grants classified as official development assistance (ODA). However, these sources of financing have been insufficient. The state budget and ODA combined cover less than one-third of the actual financing needs. Even within this limited funding, the fees collected for water delivery services only contribute a mere 6%. This demonstrates the inadequate revenue generation from the current tariff structure. The backbone and inter-district irrigation networks, which are maintained by the *State Water Resources Service* (SWRS) divisions, have received annual state funding ranging from 11 million USD to 19 million USD between 2010 and 2020. However, the required funding for these networks exceeds 50 million USD per year. As for on-farm irrigation networks, the government has allocated up to 4 million USD annually. This insufficient funding has resulted in systematic underfunding, leading to a deteriorated state of the irrigation infrastructure. To rehabilitate the irrigation infrastructure on a one-time basis, an estimated 250 million USD is needed, including 180 million USD for the on-farm irrigation networks operated by WUAs.

The provision of drinking and municipal water supply, as well as wastewater disposal services in the Kyrgyz Republic is being provided at prices that are below their cost. The payment for cold water includes the population's contribution towards wastewater disposal. Between 2009 and 2019, the average payment per person per month for cold water was 0.88 USD, and for hot water, it was 4.2 USD. However, by 2019, only 36% of all housing in the country had access to cold water, 27% had sewerage facilities, and only 7.1% had access to hot water. This means that only the population and households connected to these utilities were paying the tariffs.

In contrast, the government has been subsidizing the maintenance of water and wastewater facilities and has invested an average of 88 USD per capita per month in the municipal sector (excluding electricity and gas supply) from 2009 to 2019. This includes various projects supported by official development assistance (ODA), such as the municipal water and wastewater projects implemented by the EBRD in cooperation with the government of Switzerland through SECO since 2009. To further develop the drinking water supply and wastewater disposal systems in populated areas, the government of the Kyrgyz Republic approved the Program for the Development of Drinking Water Supply and Wastewater Disposal Systems until 2026. This program is being implemented with assistance from the EBRD and SECO. The government aims to secure 870 million USD in contributions from external donors, while providing 25 million USD as its own funds. However, without parallel reforms in tariff policy and operations, the newly constructed water and wastewater facilities will only add to the government's burden of subsidizing and maintaining the utility infrastructure.

The pricing levels are significantly below the actual economic value of water. The last increase in the cold-water tariff took place in November 2019, where it was raised by 1.5 times. However, the proposed increase is aimed at further raising the tariff to 10.45 $KGS//m^3$ (0.12 USD) of water and 3.45 KGS/USD USD/m^3 (0.039 USD) for discharged wastewater. Currently, the net cost of a cubic meter of water is stated to be 12.9 KGS (Orlova, 2023). The low pricing has contributed to the inefficient use of water resources and has hindered the generation of revenue for the water sector. Implementing a more realistic pricing system that reflects the true value of water could help incentivize more efficient water use and generate additional revenue to support the sustainable management of water resources in the Kyrgyz Republic.

Achieving the Sustainable Development Goals (SDGs), particularly SDG 6 on ensuring access to water and sanitation for all, is a critical priority for the Kyrgyz Republic. However, the water sector in the country faces significant financing challenges that threaten its ability to meet these ambitious targets. The current annual financing of around 168 million USD falls far short of the estimated 280 million USD needed, resulting in a substantial funding gap. This shortfall is largely due to the limited capacity of state budgets, as well as outdated pricing practices that fail to account for the true costs of water delivery and management. Inadequately low tariffs for irrigation, drinking water, and hydropower generation have disconnected the perceived value of water from the revenue generated, exacerbating the financial woes of the sector.

To bridge this gap and sustainably finance the necessary water infrastructure and services, the government must implement a comprehensive reform of its water pricing and tariff system. Aligning tariffs with the real economic value of water will not only generate much-needed revenue but also incentivize more efficient water use. Additionally, the government should explore innovative financing mechanisms, such as public-private partnership and greater utilization of international development assistance, to supplement its own budgetary resources. Strengthening coordination and collaboration among the various ministries and agencies involved in water resources management will also be crucial to ensure the efficient allocation and utilization of investments. By taking these critical steps, the Kyrgyz Republic can put itself on a path to achieving the SDG 6 targets and providing all its citizens with reliable and sustainable access to water and sanitation services.

4.3. Public-private partnership initiatives

Public-private partnership (PPP) has emerged as a crucial mechanism for the Kyrgyz Republic in its efforts to overcome the country's persistent "infrastructure deficit." For years, Kyrgyzstan has grappled with the deplorable condition of its roads, hospitals, schools, and other critical facilities, which has significantly impacted the quality of life for its citizens. The high level of public debt has further compounded the challenge, prompting the government to seek out new financing instruments to address this pressing issue.

The introduction of a new PPP law in 2021 marked a significant development in Kyrgyzstan's approach to this partnership model. The revised legislation has introduced several key changes, such as allowing for direct negotiations for large-scale projects, increasing competition oversight, and providing greater protection for private partners. As a result, the PPP center now oversees a portfolio of 55 projects worth over 1 billion USD, showcasing the growing significance of this collaborative approach (Aljembayeva et al., 2024).

The potential of PPP in combating poverty in Kyrgyzstan is substantial. By leveraging the combined resources and expertise of the public and private sectors, PPP initiatives can create jobs, develop affordable housing, build critical infrastructure, and implement social welfare programs - all of which are crucial components in the fight against poverty.

However, the economic efficiency of PPP in Kyrgyzstan remains a concern, and the government must address certain institutional and regulatory barriers to ensure the successful implementation of these partnerships. Reducing bureaucratic procedures, transferring more risks to the private sector, and enhancing the technical and managerial capacity of private entities are all crucial steps to improve the effectiveness of PPP initiatives. Additionally, it is essential to carefully consider the potential risks of increasing inequality, should the projects not adequately prioritize the interests of the poor population.

The Kyrgyz government has approved a comprehensive Public-Private Partnership (PPP) Program for the years 2022-2026, showcasing its commitment to leveraging private investment and strengthening the role of the private sector in developing the country's economic and social infrastructure (Government of the Kyrgyz Republic, 2022). According to the program, the government aims to implement at least 5 PPP projects in the water supply and sanitation sector, with an investment volume of around 2 billion KGS. This emphasis on the water sector is particularly significant, as access to clean water and proper sanitation is a critical issue for many Kyrgyz citizens, especially in rural areas.

The broader PPP program covers a wide range of sectors, including water, energy, healthcare, transport and communication, education, municipal infrastructure and services and agriculture with the total estimated value of all the planned PPP projects approximately 100 billion KGS.

The planned water supply and sanitation projects are at least 5 in numbers, with an investment volume of about 2 billion KGS. This program is underscoring the government's commitment to mobilizing private investment to address the country's pressing infrastructure and social service needs.

The program's objectives include improving the quality of project preparation, ensuring efficient use of resources, proper risk assessment, and enhancing the investment attractiveness of PPP projects. The list of specific PPP projects to be implemented each year will be approved annually by the Cabinet of Ministers, ensuring a flexible and responsive approach to the country's evolving development priorities.

By prioritizing PPP in the water sector and other critical areas, the Kyrgyz government is demonstrating its understanding of the pivotal role that public-private collaboration can play in overcoming infrastructure deficits and improving the quality of life for its citizens, particularly the most vulnerable populations.

CHAPTER 5. FUTURE WATER RESOURCE MANAGEMENT

5.1. Water demand for the different consumers

Although, a significant portion of surface water resources in Kyrgyzstan originate within the country's borders, only a fraction, approximately a quarter, is utilized for internal water consumption. The remaining outflow of rivers flows into the territories of neighboring countries. The exact volume of return waters, which refers to the water that returns to the rivers after use, is poorly studied but is estimated to be around 1.3 x 10^9 m^3 /year.

In terms of wastewater, the annual volume ranges from 0.71 to 1.02 x 10^9 m^3 /year (Government of the Kyrgyz Republic, 2023). However, it is important to note that this figure is likely understated as it does not account for wastewater from decentralized drainage systems in rural areas. These decentralized systems contribute significantly to the overall volume of wastewater generated in the country. Kyrgyzstan is also rich in fresh groundwater resources, with 106 identified groundwater fields. Out of these, 20 are currently being used for household and industrial water supply.

The projected reserves of fresh groundwater amount to over 13 x 10^6 m^3/year. However, it is worth mentioning that 44 groundwater fields have been thoroughly studied, which have potential freshwater reserves of 11 x 10^6 m^3/year operational reserves of 5.3x10^6 m^3/year. Overall, except for certain areas in South Kyrgyzstan, the country possesses sufficient reserves of drinking water for the long-term future. *This indicates that Kyrgyzstan's water resources can meet the current and future demands for drinking water, ensuring water security for its population*.

Approximately 90% of the diverted water in the country is used for agricultural purposes. Apart from agriculture, the remaining 10% of water is allocated for various other uses such as municipal water supply, industrial activities, forestry, and fishery. Around 6% is utilized for industrial purposes, while less than 3% is allocated for household needs, including the supply of drinking water to both urban and rural populations. Other sectors of the economy, such as forestry, fisheries, energy, and various services, collectively account for less than 1% of the total domestic water consumption. These sectors rely on the available water resources for their respective operations and development. It is important to note that hydropower engineering, which plays a significant role in Kyrgyzstan's energy sector, utilizes water for the generation of electricity. While it does not involve the extraction of water from sources, hydropower engineering still has its own water requirements to ensure the efficient production of energy.

The usage of water for industrial purposes in Kyrgyzstan has significantly decreased over the years. According to data from the National Statistical Committee, water consumption for industrial needs has reduced by three times from 254 x 10^6 m^3 in 1995 to 82.5 x 10^6 m^3 in 2020. This decline in water consumption can be attributed to various factors, including changes in industrial practices, advancements in technology, and the implementation of water conservation measures. The main objective of water consumption in the industrial sector is to ensure the return of water to the environment in a normative quality. This means that industries strive to treat and discharge water in a way that meets environmental standards to minimize any negative impact on the ecosystem. This objective aligns with sustainable water management practices and the need to preserve the quality of water resources in Kyrgyzstan.

The usage of water in the tourism and recreation sectors in Kyrgyzstan is influenced by the diverse range of hydro-mineral resources available. These resources vary in terms of mineral composition, temperature regime, formation conditions, and water manifestations, which enable their wide range of applications. The potential of mineral waters, hot springs, radon waters, sulfate waters, iron-rich waters, and other types of water is utilized by resorts, sanatoriums, and recreational facilities.

In the Kyrgyz Republic, the highest recorded figures for water intake and use were observed in 1988, with intake reaching 13.93 x 10^6 m^3/year and water use amounting to 10.05 x 10^9 m^3/year. However, between 2005 and 2012, the volume of water intake decreased to 7.5-10 x 10^9 m^3/year, primarily due to a decline in industrial output. The use of groundwater also experienced a decrease, dropping from 1 to 0.77 x 10^9 m^3 /year.

5.2. Adaptation measures for the protection and rational use of freshwater resources

A vertical decision-making structure has been established for the management of water resources. Water and land resources, as well as issues related to the country's development and the protection of water resources, are being addressed in an integrated manner. At present, a National Council on Water and Land Resources has been established under the President of the Kyrgyz Republic (herein after referred to as the National Council). The President of the Kyrgyz Republic is the Chairperson, and the Prime Minister of the Kyrgyz Republic and the Minister of Natural Resources, Ecology and Technical Supervision of the Kyrgyz Republic are the Deputy Chairpersons. The main tasks and functions of the National Council are to coordinate the activities of ministries, administrative agencies, and other state bodies in the management, utilization, and protection of water and land resources. The functions of the National Council's Secretariat are assigned to the authorized body in the field of natural resources of the Kyrgyz Republic.

According to the Decree of the Cabinet of Ministers of the Kyrgyz Republic "On Organizational Measures in Connection with the Approval of the Structure and Composition of the Cabinet of Ministers of the Kyrgyz Republic" dated November 6, 2021, No. 242, a reorganization of state bodies has been carried out. In the authorized body in the field of environmental protection, the activities related to the protection and rational use of water resources have been allocated as a separate area of activity, which has allowed for the separation of policy from economic regulation, and the consideration of management issues as a function. A separate unit has been created within the environmental protection agency, which deals with water and land issues and serves as the working body of the National Council's Secretariat. The functions of water resource management at the local level will be implemented through the regional divisions of the Ministry of Natural Resources, Ecology and Technical Supervision of the Kyrgyz Republic. To create a sustainable system for managing water resources within the river basins, it is necessary to ensure decision-making at the regional, national, and local levels.

The main sectoral tasks and indicators related to water are reflected in the strategic and programmatic documents of the Kyrgyz Republic:

- The State Program for the Development of Irrigation of the Kyrgyz Republic for 2017-2026, approved by the Decree of the Government of the Kyrgyz Republic dated July 21, 2017: No. 440;
- The National Development Strategy of the Kyrgyz Republic for 2018-2040, approved by the Decree of the President of the Kyrgyz Republic dated October 31, 2018: No. 221;
- The National Program for the Development of the Kyrgyz Republic until 2026, approved by the Decree of the President of the Kyrgyz Republic dated October 12, 2021: No. 435;
- The Program for the Development of Drinking Water Supply and Sewerage Systems in Settlements of the Kyrgyz Republic until 2026, approved by the Decree of the Government of the Kyrgyz Republic dated June 12, 2020: No. 330;

- National Water Strategy until 2040, Presidential Decree UP No. 23 from 10.02.2023.

Insufficient capacity for water resource monitoring and dilapidated State Water Cadastre system. The destruction of the organizational structure for state water accounting and the State Water Cadastre has led to ambiguity in the data on water resources. The regulatory, legal, and scientific-methodological frameworks do not correspond to the current level of development of science, technology, and technology. Currently, the capacity of the authorized agencies to assess the water resources of the Kyrgyz Republic is insufficient. The scientific institutes in Kyrgyzstan and individual experts provide ambiguous assessments of the available water resources, which leads uncertainties in data. The lack of monitoring data on water resources is due to the reduction of the observation network, types of work, and departments for hydrometeorology monitoring. The system of departmental observation networks are poor and needs to be rehabilitated.

The issues of improving the legal, regulatory, technical, and scientific-methodological foundations, as well as the metrological support of state water accounting, were addressed outside the Kyrgyz Republic. Moreover, in the 1990s, the continuity of certain specialized types of work, such as field observations of lakes and glaciers, and ensuring the metrological foundations of measurements, was interrupted. The reduction in the monitoring network and the issuance of reference and analytical information has led to insufficient data on water resources and the state of the natural environment. The State Fund of Data on Water Resources of the Kyrgyz Republic requires streamlining, regulation by normative legal acts at the state level (currently carried out at the departmental level, with no guarantee of document preservation), and increased responsibility for maintaining state funds (archival data on water resources), as well as digitization. According to the Water Resources Service of the Ministry of Agriculture of the Kyrgyz Republic, the total volume of water withdrawal in the republic over the past thirty years has varied within the range of 11.1-7.5 x 10^9 m^3/year, while the total volume of water use over the same period is 9-4.48 x 10^9 m^3/year or up to 60% of the water withdrawal volume (GoK, 2023).

Kyrgyzstan will introduce several key initiatives to establish sustainable economic mechanisms for water resource management. The country will begin collecting fees for the use of surface water resources in industrial activities. The government will also refine the regulatory framework to determine and collect these fees. A new permitting system for the use of surface water resources will be implemented in 2024, followed by a gradual transition to financing the Unified Water Information System from the state budget starting in 2025.

However, the realization of these initiatives faces several risks and challenges. Kyrgyzstan is highly vulnerable to the impacts of climate change, which introduces uncertainty and limits long-term planning. The economy's dependence on weather conditions further constrains the availability of information for decision-making. Additionally, there is a lack of sustainable financing for activities related to water resource protection and rational use. The country is also experiencing an increasing frequency of water-related disasters, which are driven by the mountainous landscape, climatic conditions, and human-induced impacts on ecosystems.

Growing demand for water, driven by population growth, urbanization, and improved living standards, is creating risks of water scarcity, depletion, and pollution. This necessitates transboundary cooperation to address water-related challenges. The construction and maintenance of infrastructure to meet the growing water demand without harming ecosystems also present significant time and resource requirements.

To address these challenges, the strategy emphasizes the need for coordinated efforts among stakeholders, led by the authorized body for natural resources. A comprehensive action plan with measurable indicators will be developed to monitor and evaluate the strategy's implementation. The results of regular monitoring will be reviewed by the National Council, and recommendations will be provided to the Cabinet of Ministers. Periodic public reporting on the progress of the strategy's implementation will also be undertaken.

The overarching goal is to establish a multilayered system for water resource management that addresses the dynamic growth in water demand, the risk of water scarcity and depletion, water pollution, and the need for transboundary cooperation - all while ensuring the sustainable and rational use of water resources in Kyrgyzstan.

5.3. Transboundary water resources management

The issues on the use of water resources of the Kyrgyz Republic by the neighboring countries in the Central Asian region (CAR) remain a source of discussions in the relations between the riparian states due to the imperfection of the legal framework in water use (Mamatkanov & Bazhanova, 2019). The downstream countries do not participate in the operation and maintenance of the hydraulic engineering and water management structures built on the territory of Kyrgyzstan and operating in the interests of these states. After gaining independence and declaring sovereign rights over natural resources, including water resources, issues have arisen between the Central Asian states, which are manifested in the following:

1. The current system of limited water distribution, i.e., the quotas established during the Soviet period. The schemes and regulations of this system are normative documents that regulate the distribution and use of water resources in the basins of transboundary rivers, where each republic has established quotas for water withdrawal volumes, irrigation norms, and irrigation areas. This situation persists today, being one of the causes of the discussions between the states.

2. The lack of an economic mechanism in interstate water use. A number of interstate hydraulic engineering structures have been built on the territory of Kyrgyzstan, through which water is supplied to neighboring states. Kyrgyzstan bears the cost of their operation from its own budget, which is not objective in a market economy.

3. The free of charge water resources can be considered a difficult situation to be resolved, this is can be considered as a root of the main problems in relations between the region countries. According to the international assessment, “Water has its own economic value for all its competing uses and should be an economic commodity,”

since it is the “free-of-charge” nature of water resources that leads to their ruthless exploitation, depletion, and environmental catastrophes, which can be observed from the example of the Aral Sea disaster.

4. The operation regime of the Toktogul reservoir. The reason for this problem lies in the lack of coordination of the mode of water discharge from the Toktogul reservoir for power generation during the cold period (interests of Kyrgyzstan) and for irrigation during the growing season (interests of Uzbekistan and Kazakhstan). The irrigation mode of operation was determined by the design specification during the construction of the reservoir in the Soviet period and was strictly followed. With the cessation of subsidized supplies and the emerging energy crisis in Kyrgyzstan, the issue of the need to more efficiently use its own hydropower capacities of the cascade of the Lower Naryn hydropower plants in the winter mode for power generation arose.

It is estimated that if 50% of the annual volume of the Toktogul reservoir is discharged according to the winter energy mode, power generation can be increased by 2.2 billion kWh and thus avoid an electricity shortage (Mamatkanov & Bazhanova, 2019). However, the country cannot resort to such an efficient option, as it must fulfill its obligations to supply water in the summer to the downstream states in accordance with the concluded Agreements. Kyrgyzstan’s own winter energy consumption is provided by power generation at thermal power plants. But in some years, with a shortage of energy carriers at thermal power plants, the country increases winter discharges to generate additional electricity. These actions lead to the flooding of settlements and agricultural lands in the lower reaches of the Syr Darya, as the riverbed is intensively developed and cannot pass higher winter flows, which causes a negative reaction from the governments of the neighboring states.

The availability and use of water resources is a critical issue for the Central Asian countries, as it impacts both their economic and political development. The UN has recognized water as an economic good that requires coordinated management. However, the Central Asian states have yet to establish a comprehensive international agreement on the sharing and allocation of transboundary water resources. The Interstate Commission for Water Coordination (ICWC), created in 1992, has facilitated some regional cooperation on water resource management. The countries have developed legal frameworks and action plans to address the environmental challenges in the Aral Sea basin. However, key challenges remain:

• There is no clear consensus on the ownership and sovereign rights over transboundary water resources. National legislations have asserted ownership, but the scope and implications have not been fully resolved at the interstate level;

• The mountainous upstream countries, like Kyrgyzstan and Tajikistan, where most water resources originate, face limitations in exercising their water rights due to the water allocation system inherited from the former Soviet era;

• Efforts by upstream countries, like Kyrgyzstan, to establish principles for fair and reasonable use of transboundary waters, as well as compensation for costs and damages still needs to be recognized by the downstream countries.

• Clear mechanisms for disagreement resolution and ensuring the protection of water resources from pollution and depletion are underdeveloped at the regional level.

Overall, the legal and institutional frameworks for transboundary water management in Central Asia remain incomplete and uneven. Continued negotiations and compromises are required to establish sustainable and equitable water sharing arrangements among the riparian countries. Strengthening regional cooperation and harmonizing national policies could help address this critical environmental and economic challenge facing the region.

The Institute of Water Problems and Hydropower of the National Academy of Sciences of the Kyrgyz Republic has put forward its proposals for their effective transboundary water utilization (Mamatkanov & Bazhanova, 2019):

Firstly, it is proposed to consider and adopt a law on payment for water as a natural resource with an assigned value, to be applied to all water users, based on a developed Methodology and tariffs. This would establish an economic mechanism for compensating the costs and damages incurred by water users, depending on the quota of transboundary water resources used in the Central Asian countries.

Secondly, it is recommended to revise and approve the strategy for the international principle of water allocation, review the quotas that satisfy all the Central Asian states, and adopt an agreement at the state level. This would help address the unresolved issues around the ownership and sovereign rights over transboundary water resources among the riparian countries.

The program to improve the efficiency of water resource use by the Central Asian states is recommended to include the following tasks:

In terms of water management, the proposals include a full transition to a basin-based management approach and the creation of basin authorities involving all water users. This is coupled with the reconstruction, restoration and modernization of irrigation and drainage systems to improve efficiency. Strengthening water user associations, improving management structures and methods, and introducing differentiated tariffs for water services are also recommended.

Specific technical measures include the introduction of water-saving irrigation technologies, restoring the training system for hydraulic engineers and irrigators, and developing incentive mechanisms for water savings at all levels. Importantly, the proposals call for a long-term state program integrating water management and agricultural development.

The overarching conclusion is that integrated water resources management (IWRM) of transboundary basins in Central Asia, which is the most objective and appropriate approach, should be based on the equal consideration of the interests of all states. This requires generating the political will among the countries to discuss and resolve all existing problems.

As an initial example, the joint Kyrgyz-Kazakh transboundary water use in the Chu and Talas river basins (described in Subchapter 6.5), which originate entirely in Kyrgyzstan, could serve as a model for developing such cooperative mechanisms in the region.

CHAPTER 6. CONCLUSION AND POLICY RECOMMENDATIONS

6.1. National Water Strategy

As Kyrgyzstan moves forward with the implementation of its National Water Strategy (NWS) (GoK, 2023), a well-designed and thorough program is essential to ensure its successful realization. This comprehensive strategy outlines a range of government programs and initiatives aimed at improving the country's water infrastructure, increasing water use efficiency, and ensuring long-term water security.

A key focus of the strategy is the recognition of the significant threats posed by climate change, including increased glacial melt, changes in precipitation patterns, and the heightened risk of water-related natural disasters such as floods and droughts. In response, the strategy outlines adaptation measures that center on enhancing water infrastructure, improving water use efficiency, and developing early warning systems to better prepare for and mitigate the impacts of these climate-driven challenges.

Alongside adaptation efforts, the strategy also emphasizes the importance of mitigation measures, which seeks to reduce greenhouse gas emissions from the water sector, such as through the increased utilization of renewable energy sources for water pumping and treatment processes. This holistic approach to addressing the water-climate nexus underscores the government's commitment to building a more resilient and sustainable water management system.

Moreover, the strategy places a strong emphasis on the protection of the country's water resources, recognizing the need to safeguard against pollution and overexploitation. This is reflected in the development of enhanced regulations, improved water quality monitoring, and the promotion of integrated water resources management practices. The establishment of river basin management plans, water protection zones, and the implementation of sustainable agricultural techniques are all key elements of this comprehensive water resource protection framework.

Underpinning the strategy's implementation is a detailed National Action Plan, which outlines specific activities, responsible agencies, and timelines to ensure the successful realization of the strategy's objectives. This action plan covers a wide range of areas, including infrastructure development, institutional capacity building, stakeholder engagement, and international cooperation on transboundary water issues, demonstrating the government's commitment to a multi-faceted approach to water management.

At the core of the NWS implementation program, should be the development and introduction of an *Integrated Water Resources Management* (IWRM) approach. This holistic framework for managing water resources considers the interactions between surface water, groundwater, and ecosystems, as well as the diverse needs and priorities of various stakeholders. Establishing the necessary institutional structures, policies, and processes for IWRM will lay the foundation for sustainable and equitable water resource management. A critical aspect of the implementation program will be the actual transition from the current centralized approach to a decentralized, basin-level management system. This will involve delineating and empowering river basin organizations to oversee the planning, allocation, and protection of water resources within their respective basins. Developing the institutional capacities and coordination mechanisms for effective basin management will be a key priority.

Fee rates for water extraction/removal and use will be differentiated depending on the purpose of water resources use: for drinking and domestic water supply, for the needs of industry, energy, irrigated farming, use of the water body water area without water withdrawal, as well as on the amount of available water resources in each specific section of the basin. Differentiation of payments in accordance with the priorities of preferential and safe sustainable water use within the basin area sets the basis for an integrated approach to water policy implementation. In the world practice, there are various situations when surface water can be bought and sold at a price determined by the mechanism of supply and demand. Insurance of the risk of damage and harm to the property of the owner as a result of negative impact of water will reduce the damage and harm.

Robust water resource accounting and monitoring systems must be put in place as part of the implementation program. This includes establishing comprehensive mechanisms for measuring, recording, and reporting on the availability, allocation, and use of water resources across the country. Advanced monitoring technologies and data management platforms will be essential to provide the necessary information for evidence-based decision-making.

Given Kyrgyzstan's vulnerability to the impacts of climate change, the implementation program must carefully consider the risks and threats posed by potential changes in flow regimes and reductions in water availability. This will involve conducting detailed assessments of climate change projections, evaluating their implications for water resources, and developing adaptation strategies to build resilience and ensure water security.

6.3. Water use in agriculture and engagement of private sector

Currently, Kyrgyzstan's water sector is deeply intertwined with the agricultural sector, as agriculture accounts for a staggering 93% of the country's renewable freshwater withdrawals. Recognizing this strong linkage, the effective implementation of NWS must be accompanied by comprehensive reforms and interventions in the agricultural sector. Achieving sustainable agricultural development in the country will necessitate a thorough review and restructuring of the country's agricultural system. The current fragmented nature of small-scale farms hinders the sector's ability to efficiently utilize water resources and adopt modern, productive farming practices. Addressing this challenge will require a multi-pronged approach.

The establishment of a well-functioning secondary market for agricultural land can serve as a catalyst for transforming the agricultural landscape. By facilitating the consolidation of small farms, this market-based mechanism can attract private investment and enable the development of medium and large-scale farming operations. The influx of private capital and the merging of smaller farms into more viable units can lead to the adoption of advanced irrigation technologies, improved water management practices, and increased agricultural productivity (Ministry of Agriculture and Melioration of the Kyrgyz Republic, 2015). Alongside the development of a secondary land market, the government should proactively encourage the consolidation of small farms into more efficient units, such as agricultural cooperatives or larger, individually operated farms. This can be achieved through targeted incentives, technical assistance, and the removal of regulatory barriers that currently hinder the merger of small landholdings. By enabling small-scale farmers to pool their resources and expertise, this approach can enhance their collective bargaining power, access to markets, and overall competitiveness. In parallel with the consolidation of small farms, the government should also prioritize the development and support of medium and large-scale farming operations, either through direct ownership or long-term leasing arrangements. These larger, more professionally managed farms can leverage economies of scale, adopt advanced irrigation technologies, and implement more efficient water management practices, thereby contributing to the overall sustainability of the agricultural sector.

The consolidation of land ownership and the emergence of larger, more sophisticated farming operations can have a positive impact on the relationships between water suppliers and water users. With fewer, but more organized and responsible water users, the coordination and cooperation between the water sector and the agricultural sector can be significantly enhanced. This can lead to better water allocation, improved water infrastructure management, and the implementation of sustainable irrigation practices.

The Government of Kyrgyzstan has taken a significant step by introducing payments for the use of water as a natural resource. This move aligns with the relevant provisions in the Water Code and will help alleviate the heavy burden on the government's centralized budget in financing and managing the water sector. Within the next 3-5 years, there is a chance to undertake meaningful reforms in these sectors, including a reasonable increase in tariffs, enhanced accountability of service operators, and structural changes to improve the efficiency of services and fee/payment systems. To justify the imposition of charges for water as a natural resource or the increase in tariffs for water as a utility, water for irrigation, or charges for water-related ecosystem services, a comprehensive economic valuation of water resources would be timely. This study would comprise three key components: an economic valuation of water resources, an economic valuation of ecosystem services, and an assessment of the appropriate compensation for the depletion of water, rivers, and riverbanks as natural resources.

The economic valuation of ecosystem services would seek to quantify the diverse benefits that the natural environment, including rivers, watersheds, and associated habitats, provides to the people of Kyrgyzstan. This analysis would help inform the development of policies and mechanisms to ensure the sustainable management and conservation of these vital ecosystems, which play a crucial role in regulating water flows and maintaining water quality.

Finally, the assessment of compensation for the depletion of water, rivers, and riverbanks as natural resources would aim to determine the appropriate level of payments required to offset the impacts of human activities, such as hydropower generation, on the natural environment. If integrated into electricity tariffs, these compensation payments could be strategically directed towards afforestation, reforestation, and other initiatives that enhance the natural water-saving capacity of the upper watershed areas, thereby helping to compensate for the effects of glacier melt and other climate change-related impacts.

Additionally, a special investigation could be conducted to determine the appropriate level of compensation to the natural environment due to hydropower generation. If this payment is integrated into electricity tariffs, it could be purposefully directed towards afforestation and reforestation in the upper reaches to increase the natural water-saving capacity of the catchments and compensate for glacier melt.

6.4. Integrated water resources management approach

It is possible to explore the feasibility of charging municipalities for water as a natural resource, considering the adverse impacts that urbanization has on water bodies and the surrounding environment. This could lead to urban greening initiatives, improved drainage systems, and the introduction of watershed management practices within populated areas. To establish structured relationships between water suppliers and recipients, it is necessary to introduce comprehensive accounting for water as a public utility, irrigation water tariffs, and payments for water as a natural resource. Payers should be assured that their payments are directly linked to the services rendered or specific basin-level initiatives, and the basin administration should be responsible and accountable for the utilization of these funds, thereby generating interest in IWRM (UNECE, 2013).

The creation of basin authorities based on a “top-down” approach is the way forward, but this should be a gradual process. Wherever there are signs of self-sufficiency in internal management, these basins should be prioritized for the transition to a basin-level management system. This expanded basin management should encompass not only water for irrigation, but also the care for rivers, watersheds, and a broader range of water users. Adopting a “bottom-up” approach is crucial to structure and strengthen the capacity of WUAs and farmers as the primary water users. Sustainable farms are more likely to be willing to pay higher prices for timely and sufficient water supply, and invest in water use efficiency. As the number of such resilient farms grows, WUAs will be better positioned to increase the amount of water supplied and reduce transportation losses. Stronger WUAs, in turn, will have the ability to pay reasonable fees to cover the cost of water services and invest in local infrastructure.

Given the impacts of climate change, long-term average water flow data may no longer be reliable. Therefore, efforts to monitor hydrology and water resources, including the monitoring of water withdrawal and use throughout southern

Kyrgyzstan, should be significantly enhanced. Accurate and up-to-date data will be crucial for informed decision-making and to address potential conflicts over transboundary water resources. Pilot projects on water-saving, water-efficient, and water-productive agriculture should be supported, including the development of supply and maintenance services for efficient irrigation technologies. Established local credit lines and other financing mechanisms should be maintained to facilitate the adoption of these water-smart practices. Additionally, capacity-building activities should be undertaken at the level of basin administrations, WUAs, other water users, local administrations, and community leaders to support the implementation of basin management in Kyrgyzstan.

By integrating economic mechanisms, institutional reforms, and capacity-building efforts, Kyrgyzstan can establish a comprehensive and sustainable approach to water management, addressing the country's pressing water-related challenges and ensuring the long-term prosperity of its water resources, which is beneficial not only for the country, but also for the whole region.

6.5. Transboundary cooperation for sustainable water management

As a country situated in a transboundary river basin, Kyrgyzstan is recommended to prioritize water diplomacy efforts within the implementation program. This includes strengthening regional cooperation mechanisms, engaging in constructive negotiations with neighboring countries, and developing the necessary legal and institutional frameworks for effective management of shared water resources (Soliev, 2015). Broader trade and economic relations also supports this aim. By aligning its water management strategies with its trade and economic development objectives, the country can position itself to derive greater overall benefits for its population and economy. This may involve exploring opportunities for cross-border trade in agricultural products, hydropower, and other water-intensive goods and services, where Kyrgyzstan's water resources can provide a comparative advantage.

Rather than approaching water relations from a zero-sum perspective, Kyrgyzstan should strive to cultivate partnerships with its neighbors that are centered on mutual interests and win-win outcomes. This may involve negotiating water-sharing agreements that incorporate broader economic incentives and trade-offs, such as access to regional markets, joint infrastructure development, or energy exchange arrangements. Kyrgyzstan's significant water resources, particularly during periods of surplus, can be strategically viewed as an opportunity to enhance its economic well-being and regional influence. By developing innovative water-energy nexus projects, such as hydropower generation and cross-border electricity trading, the country can generate revenue and solidify its position as a regional energy hub. Additionally, Kyrgyzstan could explore the possibility of selling or exchanging its excess water with neighboring countries, provided that such arrangements are negotiated equitably and with due consideration for environmental and social impacts.

To effectively integrate water policy with its broader trade and economic interests, Kyrgyzstan can invest in building its institutional and human capacities in water relationship. This may involve establishing dedicated teams or units within relevant government agencies to spearhead cross-border water negotiations, develop strategic partnerships, and leverage water resources for economic benefit. Additionally, enhancing the technical and negotiation skills of water experts and policymakers will be crucial for navigating the complex dynamics of regional water resource management.

The reliance on renewable water flows for hydropower generation makes Kyrgyzstan's energy sector highly susceptible to the effects of climate change. Projected changes in precipitation patterns, glacial melt, and shifting river flow regimes could significantly disrupt the reliable supply of water resources required to maintain stable hydropower production. This vulnerability highlights the need for Kyrgyzstan to consider alternative energy sources that are more resilient to the uncertainties posed by climate change.

The successful example of the Agreement on the Use of Water Management Facilities of Intergovernmental Status on the Chu and Talas Rivers between Kyrgyzstan and Kazakhstan demonstrates the potential for mutually beneficial collaboration based on the principles of good-neighborliness, equality, and mutual assistance (Dzhumagulov et al., 2024).

The recent positive developments in interstate relations, particularly between Kyrgyzstan and Uzbekistan, are particularly encouraging. The signing of the agreement on the joint management of the Orto-Tokoi (Kasansai) reservoir and the Kempir-Abad (Andijan) reservoir showcases a shift towards a more constructive dialogue and cooperation on the use of shared water resources. These agreements ensure the equitable distribution of water and the fair allocation of operational costs, promoting sustainable water use and environmental protection.

Looking ahead, Kyrgyzstan's legal policy in the field of transboundary water management should continue to focus on settling relations with neighboring states through the conclusion of bilateral international agreements. The successful experiences of multilateral cooperation on the use of international watercourse systems in other regions of the world, as well as the models developed within the framework of the United Nations and other organizations, can serve as valuable references for Kyrgyzstan. In the long term, considering the fundamental importance of international watercourses for the development of the economies in the region, there may be a need to explore the possibility of creating a supranational interstate structure, akin to the European Coal and Steel Community or Euratom, to ensure the environmentally safe, politically equitable, and economically mutually beneficial exploitation of water resources in Central Asia.

Strengthening regional integration and fostering continued positive diplomatic relations will be crucial for Kyrgyzstan in its efforts to achieve sustainable and cooperative management of transboundary water resources. By building on the recent successes and learning from the experiences of other regions, Kyrgyzstan can play a pivotal role in shaping a future where the equitable and responsible use of shared water resources contributes to the overall prosperity of Central Asia.

References

Abbink, K., Moller, L. C., & O'Hara, S. L. (2009). Sources of mistrust: an experimental case study of a central asian water conflict. Environmental and Resource Economics, 45(2): 283-318. https://doi.org/10.1007/s10640-009-9316-2

ADB (2014) Climate change and sustainable water management in Central Asia. Asian Development Bank, Central and West Asia Working Paper Series No 5.

Alamanov, A. & Mikkola, H. (2011). Is biodiversity friendly fisheries management possible on Issyk-Kul Lake in the Kyrgyz Republic?. Ambio, 40(5): p.479.

Alifujiang, Y., Abuduwaili, J., Ma, L., Samat, A. and Groll, M. (2017). System Dynamics Modeling of Water Level Variations of Lake Issyk-Kul, Kyrgyzstan. Water, 9(12): p.989.

Aljembayeva, N., Imankulova, S., Nogoibayeva, R., & Aknazarova, R. (2024). The role of public-private partnership in overcoming poverty in the Kyrgyz Republic. BIO Web of Conferences, 83, 07006. https://doi.org/10.1051/bioconf/20248307006

Alymkulova, B., Abuduwaili, J., Issanova, G. and Nahayo, L. (2016). Consideration of water uses for its sustainable management, the case of Issyk-Kul Lake, Kyrgyzstan. Water, 8(7): p. 298.

Barandun, M., Huss, M., Usubaliev, R., Azisov, E., Berthier, E., Kääb, A., Bolch, T. and Hoelzle, M. (2018). Multi-decadal mass balance series of three Kyrgyz glaciers inferred from modelling constrained with repeated snow line observations. Cryosphere, 12, 1899–1919.

Betz, F., Chymyrov, A., Lauermann, M., Cyffka, B., & Chontoev, D. (2022). Assessing the impacts on natural ecosystems of the future Kambarata-1 hydropower station on the Naryn river, Kyrgyzstan: a GIS-based approach. In *GI-Forum* (Vol. 10, No. 1: p. 48-57).

https://doi.org/10.1553/giscience2022_01_s48

BneIntelliNews (2024). Small hydro to also play big role in rejuvenating Kyrgyzstan's worn-out power infrastructure. https://www.intellinews.com/small-hydro-to-also-play-big-role-in-rejuvenating-kyrgyzstan-s-worn-out-power-infrastructure-329479/

Constitution of the Kyrgyz Republic (2021). https://constsot.kg/wp-content/uploads /2022/06/constitution-of-the-kyrgyz-republic.pdf

Deng, H., & Chen, Y. (2017). Influences of recent climate change and human activities on water storage variations in Central Asia. Journal of Hydrology, 544, 46–57.

Dixon, S.G. and Wilby, R.L. (2019). A seasonal forecasting procedure for reservoir inflows in Central Asia. Rivers Research and Applications – Special Issue.

Dzhumagulov, A. M., Baigazieva, D. M., & Eshmuradova, N. D. (2024). Transboundary water management in Kyrgyzstan: international law aspects. BIO Web of Conferences, 107, 04003. https://doi.org/10.1051/bioconf/202410704003

Farinotti, D., Longuevergne, L., Moholdt, G., Duethmann, D., Mölg, T., Bolch, T., ... & Güntner, A. (2015). Substantial glacier mass loss in the Tien Shan over the past 50 years. Nature Geoscience, 8(9), 716-722. https://doi.org/10.1038/ngeo2513

FAO (2012). AQUASTAT Country Profile - Kyrgyzstan. Food and Agriculture Organization of the United Nations (FAO), Rome, Italy. https://openknowledge.fao.org/server/api /core/bitstreams/f094b9e9-f39e-4a59-a920-5d989a19f5f5/content

Gan, R., Luo, Y., Zuo, Q., & Sun, L. (2015). Effects of projected climate change on the glacier and runoff generation in the Naryn River Basin, Central Asia. Journal of Hydrology, 523, 240–251.

GFDRR (2011). Kyrgyz Republic. Climate Risk and Adaptation Country Profile.

Government of the Kyrgyz Republic (2005). The Water Code (WC) of the Kyrgyz Republic. https://faolex.fao.org/docs/pdf/kyr49854E.pdf

Government of the Kyrgyz Republic (2020). Program for the development of drinking water supply and sewage systems in populated areas of the Kyrgyz Republic until 2026. https://faolex.fao.org/docs/pdf/kyr205204.pdf

Government of the Kyrgyz Republic. (2022). The Cabinet of Ministers approved the program for 2026. PPP Center of the Kyrgyz Republic. https://ppp.gov.kg/tpost/rhlzb9vvb1-kabinet-ministrov-utverdil-programmu-gch

Government of the Kyrgyz Republic (2023). Presidential Decree UP No. 23 validating the National Water Strategy until 2040. https://cbd.minjust.gov.kg/434906/edition/1230660/ru

International Energy Agency (2020). Kyrgyzstan energy profile. https://iea.blob.core. windows.net/assets/c71e642f-e0fd-4c9c-b910-c7adda2cf6c9/KyrgyzRepublicEnergyProfile.pdf

Kretova, Z. (2020). Assessment of Climate Change in the Kyrgyz Republic under the IFAD Project "Livestock Development and Market-2". IFAD: BiShkek, Kyrgyztsan.

Lemenkova, P. (2013). Current problems of water supply and usage in central asia, tian shan basin. "Environmental and Climate Technologies 2013" Conference Proceedings. https://doi.org/10.7250/iscect.2013.002

Liang, L., Zhang, F., & Qin, K. (2021). Assessing the vulnerability of agricultural systems to drought in Kyrgyzstan. Water, 13(21), 3117. https://doi.org/10.3390/w13213117

Li, Y., Ma, L., Abuduwaili, J., Li, Y., & Abdyzhapar Uulu, S. (2021). Spatiotemporal distributions of fluoride and arsenic in rivers with the role of mining industry and related human health risk assessments in Kyrgyzstan. Exposure and Health, 1-14. https://doi.org/10.1007/s12403-021-00417-5

Mamatkanov, D. M., & Bazhanova, L. V. (2019). Transboundary water resources of Central Asia and problems of their effective use. Institute of Water Problem and Hydropower of the Kyrgyz Republic.

Ministry of Agriculture and Melioration of the Kyrgyz Republic (2015). Modern irrigation technologies and possibility of their application in Kyrgyzstan.

National Statistical Committee of the Kyrgyz Republic (2022). Environment in the Kyrgyz Republic 2017-2021. http://www.stat.kg/media/publicationarchive/c210d76d-91e9-4e8e-a597-e49217759846.pdf

National Statistical Committee of the Kyrgyz Republic (2024). Yield of major agricultural crops in Kyrgyz Republic. https://stat.gov.kg/en/opendata/category/183/

OECD (2016). Reforming irrigation tariffs in Kyrgyzstan, in Reforming Economic Instruments for Water Resources Management in Kyrgyzstan, OECD Publishing, Paris. https://doi.org/10.1787/9789264249363-8-en

OECD (2019). Strategic Infrastructure Planning for Sustainable Development in the Kyrgyz Republic

Orlova, M. (2023). Drinking water tariff in Bishkek planned to be increased annually. 24.kg. news agency. https://24.kg/english/266105__Drinking_water_tariff_in_Bishkek_planned_to_be_ increased_annually/

OSCE (2010). Report on the assessment of the activities of Water User Associations in the southern regions of the Kyrgyz Republic. https://www.osce.org/files/f/documents/d/3/76142.pdf

Parpieva, N., Matikeyeva, N., Sheralieva, Z., Adylbekova, N., & Amatova, U. (2023). Resource potential for the sustainable development of agriculture in the Kyrgyz Republic. In E3S Web of Conferences (Vol. 380: p. 01022). EDP Sciences. https://www.e3s-conferences.org/articles/e3sconf/pdf/2023/17/e3sconf_stdaic2022_01022.pdf

Pfeffer, W. T., Arendt, A. A., Bliss, A., Bolch, T., Cogley, J. G., Gardner, A., ... & Sharp, M. (2014). The randolph glacier inventory: a globally complete inventory of glaciers. Journal of Glaciology, 60(221), 537-552. https://doi.org/10.3189/2014jog13j176

Reyer, C. P., Otto, I. M., Adams, S., Albrecht, T., Baarsch, F., Cartsburg, M., ... & Stagl, J. (2017). Climate change impacts in Central Asia and their implications for development. Regional Environmental Change, 17, 1639-1650.

Rost, K. T., Ratfelder, G., & Topbaev, O. (2015). Problems of rural drinking water supply management in Central Kyrgyzstan: a case study from Kara-Suu village, Naryn Oblast. Environmental Earth Sciences, 73(2), 863-872.

Sadyrov, S., Tanaka, K., Satylkanov, R., Khujanazarov, T., Touge, Y., & Fujita, K. (2024). Modelling runoff components and hydrological processes in glaciated catchments of the inner Tien-Shan, Kyrgyzstan. Frontiers in Earth Science, 11, 1306476.

Shabolotova, Z. (2020). Integrated energy and water resource management in support of sustainable development in South-East Europe and Central Asia: Case study on the application of UNFC to energy and water resources of Kyrgyzstan. UNECE. https://unece.org/fileadmin/ DAM/energy/se/pdfs/UNFC/proj/integrated_water_RM/Case_studies/UNFC_Case_Study_Kyrgyzstan.pdf

Sorg, A., Bolch, T., Stoffel, M., Solomina, O., & Beniston, M. (2012). Climate change impacts on glaciers and runoff in Tien Shan (Central Asia). Nature Climate Change, 2(10), 725-731.

Soliev, I., Wegerich, K., & Kazbekov, J. (2015). The costs of benefit sharing: historical and institutional analysis of shared water development in the ferghana valley, the syr darya basin. Water, 7(12), 2728-2752. https://doi.org/10.3390/w7062728

Strelkovskii, N., Komendantova, N., Sizov, S., & Rovenskaya, E. (2020). Building plausible futures: Scenario-based strategic planning of industrial development of Kyrgyzstan. Futures, 124, 102646.

Tricht, L. V., Huybrechts, P., Breedam, J. V., Fürst, J. J., Rybak, O., Satylkanov, R., ... & Malz, P. (2020). Measuring and inferring the ice thickness distribution of four glaciers in the tien shan, kyrgyzstan. Journal of Glaciology, 67(262), 269-286. https://doi.org/10.1017/jog.2020.104

UNECE (2013). National Policy Dialogue on Integrated Water Resources Management. https://unece.org/DAM/env/water/publications/NPD_Publication_2013/NPD_IWRM_KG_2013_en.pdf

UNECE (2015). Study of suitable irrigation technologies for Kyrgyzstan. https://unece.org/DAM/env/water/meetings/NPD_meetings/Publications/2015/Study_of_suitable_irrigation_technologies_for_Kyrgyzstan_ENG.pdf

Water Resources Service of the Ministry of Agriculture of Kyrgyz Republic (2022, 2024). DWRLI Home. https://www.water.gov.kg/index.php?lang=en

WB, (2016). Kyrgyz Republic: Agricultural Sector Risk Assessment (Report No. 103078-KG). https://openknowledge.worldbank.org/server/api/core/bitstreams/fe6a5b1e-2548-5d41-9aa9-b7a6109f57e4/content

WB (2016). Sustainable Rural Water Supply and Sanitation Project. https://documents. vsemirnyjbank.org/ru/publication/documents-reports/documentdetail/573121475460021965/kyrgyz-republic-sustainable-rural-water-supply-and-sanitation-project

WB (2018). Climate-Resilient Agriculture in the Kyrgyz Republic. CSA Country Profiles for Asia Series. International Center for Tropical Agriculture (CIAT). World Bank, Washington, D.C. 28 p. https://climateknowledgeportal.worldbank.org/sites/default/files/2019-06/CSA%20_Profile_ The%20Kyrgyz%20Republic.pdf

WB & ADB (2021). Climate Risk Country Profile: Kyrgyz Republic. https://www.adb.org/sites/default/files/publication/706596/climate-risk-country-profile-kyrgyz-republic.pdf

WB (2022a). New Financing package of $100 million to enhance water service provision in Kyrgyz Republic, supported by the World Bank. https://www.worldbank.org/en/news/press-release/2022/04/19/new-financing-package-of-100-million-to-enhance-water-service-provision-in-kyrgyz-republic

WB (2022b). Project Appraisal Document on a Proposed Credit and Grant to the Kyrgyz Republic for a Climate Resilient Water Services Project

TÜRKİYE

LIST OF ABBREVIATIONS

BMC	Basin Management Committees
CAP	European Union Common Agricultural Policy
DSI	General Directorate of State Hydraulic Works
ENSTİTUSU	Ankara Univercity, Water Management Institute
EU	European Union
GDWM	General Directorate of Water Management (former)
GoT	Government of Türkiye
ICoI	Istanbul Chamber of Industry
IPPC	Integrated Pollution Prevention and Control
IWRM	Integrated Water Resources Management
MAF	Ministry of Agriculture and Forestry
MoEUCC	Ministry of Environment, Urbanization, and Climate Change
MoEU	Ministry of Environment and Urbanization (former)
MFWA	Ministry of Forestry and Water Affairs (former)
O&M	Operation and Maintenance
OECD	The Organization for Economic Co-operation and Development
PWMC	Provincial Water Management Coordination Committee
RBMP	River Basin Management Plan
SUEN	Turkish Water Institute, MoAF
TAGEM	General Directorate of Agricultural Research and Policies
TEMA	The Turkish Foundation for Combating Soil Erosion, Reforestation and the Protection of Natural Habitats
TZOB	The Union of Turkish Chambers of Agriculture
TSMS	Turkish State Meteorological Service
TUBITAK	The Scientific and Technological Research Council of Türkiye
TUIK	The Turkish Statistical Institute
USIAD	International Industrialists and Businessmen Association
UNICEF	United Nations International Children’s Emergency Fund
WEAP	Water Evaluation and Planning System
WHO	Uited Nations World Health Organization
WFD	European Union Water Framework Directive
WUU	Water User Union
WWF	World Wildlife Fund

EXECUTIVE SUMMARY

As global population growth and climate change intensify, water management is becoming a critical challenge that demands a combination of technological innovation, sustainable practices, and adaptive governance. The distribution of sectoral water use may differ depending on a country's level of development. In Türkiye, based on the results of 2022, out of the total water consumption of 57 billion/m^3, 44 billion m^3 of water (77%) is used for irrigation purposes, while 13 billion/$m^3$of water (23%) is used for drinking water and industrial purposes (12% and 11%, respectively).

According to the Falkenmark water stress index, a country experiences water stress when per capita annual available water falls below 1700/m^3[7] In Türkiye, this figure has dropped from 1652/m^3/cap/year (in 2000) to 1313/m^3/cap/year (in 2022), placing the country among those facing water stress. Some basins, such as Burdur, Akarçay, Gediz, Marmara, and Küçük Menderes, have less than 500m^3/cap/year, indicating absolute water scarcity, while others like North Aegean, Asi, Susurluk, and Sakarya basin face significant water scarcity. In addition to this, Türkiye has a semi-arid climate and climate change model studies shows temperature increases in all basins by 2100 for both favorable and unfavorable scenarios including temperature rise to 6^0C in some regions. Such temperature increases can exacerbate water stress, affecting agriculture and water supply negatively by influencing the quantity and distribution of water resources.

To combat this, Türkiye is implementing measures to use water more efficiently in all sectors. In agricultural irrigation, which is a major water user sector, efficiency improvements aim to raise irrigation efficiency from 50.4% in 2021 to 60% by 2030 and 65% by 2050. The irrigated land area has reached up to 7.1 million ha. in 2023 and it is aimed to be enlarged to 8.6mln/ha in the future. Training programs covering modern irrigation techniques and the use of solar energy systems are provided to farmers, alongside extension materials and digital platforms to support learning and implementation.

The average water loss rate in drinking water distribution networks in Türkiye, which was 39% in 2015, has been reduced to 33.54% in 2021 due to the maintenance activities carried out. And it is aimed to limit the water loss rate to 25% until 2033 and 10% in 2040. Besides this, Türkiye is integrating Integrated Pollution Prevention and Control (IPPC) approach into its industrial projects which focuses on protecting the environment by minimizing emissions from industrial activities through Best Available Techniques (BAT), resource efficiency, and adherence to environmental standards. Industrial water efficiency initiatives in 30 water-intensive sectors show that up to 50% water savings can be achieved by adopting cleaner production practices. Key measures include using pressurized systems for equipment cleaning, reusing treated water, optimizing backwash frequencies, improving production planning, developing water-saving action plans, monitoring water and wastewater, harvesting rainwater, using closed-circuit cooling, recovering boiler blowdown, minimizing leaks, and enhancing steam systems.

Since becoming a candidate for EU membership, Türkiye has aligned its laws with EU legislation, particularly on “Water Assets” under the “Environment Chapter” opened in 2009. This includes complying with the EU Water Framework Directive and developing River Basin Management Plans (RBMPs), which involve characterizing basins, addressing issues, protecting key areas, monitoring and program of measures. By 2016, Türkiye had worked with stakeholders to integrate natural resource plans with RBMPs and launched water allocation projects to support basin-based management.

As part of the European Green Deal, Türkiye created a Green Deal Action Plan with nine focus areas, including water reuse and preparing a “Water Reuse National Master Plan” and a guidance document on water footprint. Additionally, draft studies for a comprehensive “Water Law” have been prepared, aimed at sustainable water management by consolidating authority and aligning with the “Water Framework Directive”. In 2019, Türkiye released a “National Water Plan” to guide policy, emphasizing the need to finalize the Water Law and improve water resource efficiency in line with basin-based management goals for 2019-2023. In addition to this, integrating water management with clean energy initiatives is essential to reduce environmental impacts and support Türkiye’s goal of achieving net-zero carbon emissions by 2053, as part of its Paris Agreement obligations. Aligning water and energy policies can create synergies that benefit both sectors, promoting sustainable development and minimizing resource conflicts.

Continuous monitoring and improvement at both basin and regional levels, encouraging collaboration among stakeholders for effective governance is important for Türkiye in the context of water management strategies. Transboundary water management is also essential, requiring international agreements and cooperation to manage shared water resources equitably by integrating water-efficient practices across agriculture, industry, and urban planning to balance stakeholder needs and reduce conflicts.

In conclusion, Integrated Water Resources Management (IWRM) is critical for coordinating water, land, and related resources across sectors, ensuring a comprehensive approach to water management. Addressing these challenges requires collaboration among governments, industries, and communities to secure long-term water availability and adequate quality. In this context, Türkiye, as a candidate for EU membership and aligned its laws with EU legislation, puts in effort on balancing innovation, regulation, and community engagement, fostering resilience, and promoting green growth for future generations towards a sustainable water-secure future.

CHAPTER 1. WATER AVAILABILITY, ABSTRACTION AND DELIVERY

1.1. Available water resources and water balance

Türkiye acts as a bridge between the East and the West. Three percent (3%) of Türkiye's surface area is located on the European continent (Thrace), with the rest situated on the Asian continent (Anatolia). Türkiye is located between 26^o – 45^o east longitudes and 36^o – 42^o north latitudes. The total area of our country is approximately 780,000 km^2. Türkiye shares borders with Greece and Bulgaria to the west, Georgia, Armenia, Azerbaijan/Nakhchivan, and Iran to the east, and Syria and Iraq to the south (DSI, 2024).

The semi-arid climate conditions in Türkiye underscore the vital importance of water resources. The fact that three sides of Türkiye are surrounded by seas, the extension of high mountain ranges along the coasts, the increase in altitude from west to east, and the distance from the coast all contribute to variations in temperature, precipitation, and winds in Türkiye, depending on the region and time (Capar, 2019).

In addition to the semi-arid climate conditions in Türkiye, climate change model studies conducted as part of the *İklimSu Project* completed by *The Ministry of Agriculture and Forestry* in 2016 showed that temperature increases could occur in all basins of Türkiye by 2100 for both favorable and unfavorable scenarios. According to these studies, temperature increases of up to 6^oC are predicted in some regions. Such temperature increases can exacerbate water stress, affecting agriculture and water supply negatively by influencing the quantity and distribution of water resources (MoAF, 2016). Therefore, combating climate change and ensuring sustainable management of water resources are of paramount importance. Mitigating the effects of climate change and implementing adaptation measures are critical steps towards ensuring the healthy transfer of water resources to future generations.

In Türkiye, the annual average precipitation is approximately 574 mm, which corresponds to an average of 450 x 10^9 m^2/year. The Eastern Black Sea Region receives the highest precipitation (1.200 – 2.500 mm/year), while the Inner Anatolia Region (around Lake Tuz) receives the least (250 – 300 mm/year). Except for coastal settlements in the Mediterranean and Southern Aegean Regions, snowfall occurs during the winter months in other regions of Türkiye. Within the framework of current technical and economic conditions, the surface water potential that can be used for various purposes is estimated to be an average of 94 billion/ m^3 per year, along with the groundwater potential determined as 18 billion/m^3. Thus, the total renewable surface and groundwater potential of Türkiye amount to an average of 112× 10^9 m^3 /year, of which 57× 10^9 m^3 are currently being utilized (DSI, 2024b) (Table 1).

Türkiye consists of 25 river basins (Figure 2). Most of the rivers in our country originate within the borders and flow into the sea within the country. The most important rivers that originate within our borders and flow into the sea from our coasts are the Kızılırmak (1,151km), Sakarya (824km), Büyük Menderes (584 km), Seyhan (560km), Yeşilırmak (519km), Ceyhan (509km), Gediz (275km), and Küçük Menderes (129km). The rivers that

Figure 1. River basins of Turkiye

originate within our borders and flow into the sea from the coasts of other countries are the Euphrates (1,263 km within Türkiye), Tigris (512km within Türkiye), Çoruh (354km within Türkiye), Kura (189km within Türkiye), and Aras (548km within Türkiye) rivers. The Asi (88km within Türkiye) and Meriç (187km within Türkiye) rivers originate from the territories of other countries and flow into the sea along our coasts (DSI, 2024b).

Table 1. Surface Water Potential of Türkiye's Basins

Basin No	Basin	Watershed area (km^2)	Average annual flow (km^3)	Contribution to total potential (%)
01	Meric – Ergene	14,486	17	0.9
02	Marmara	23,074	74	4.0
03	Susurluk	24,319	50	2.7
04	Northern Aegean	9,861	20	1.1
05	Gediz	17,137	18	1.0
06	Kucuk Menderes	6,963	06	0.3
07	Buyuk Menderes	25,960	30	1.6
08	Western Mediterranean	20,956	65	3.5
09	Antalya	20,249	129	7.0
10	Burdur Lake	6,294	02	0.1
11	Akarcay	7,995	04	0.2
12	Sakarya	63,303	65	3.5
13	Western Black Sea	28,855	108	5.8
14	Yesilirmak	39,595	70	3.8
15	Kizilirmak	82,181	70	3.8

Continuation of Table 1

16	Konya Closed	49,930	24	1.3
17	Eastern Mediterranean	21,150	76	4.1
18	Seyhan	22,035	62	3.3
19	Asi	7,886	18	1.0
20	Ceyhan	21,391	77	4.2
21	Euphrates-Tigris	176,143	563	30.4
22	Eastern Black Sea	22,846	164	8.9
23	Coruh	20,248	70	3.8
24	Aras	27,775	45	2.4
25	Van Lake	17,861	26	1.4
Total		778,493	18,537	100

Groundwater is a crucial resource for domestic and irrigation purposes, especially in areas where surface water sources are scarce in Türkiye. Groundwater-related activities, including investigation, withdrawal, allocations, and licensing, are overseen by the General Directorate of State Hydraulic Works (DSI) in Türkiye. DSI conducts monthly monitoring of groundwater levels at wells, supplemented by additional seasonal observation stations. DSI has been conducting hydrogeological investigation studies across Türkiye since the 1950s, although these efforts have not yet covered the whole country. Based on hydrogeological investigation reports (DSI, 2024c), Türkiye's designated groundwater potential stands at 23 billion/m^3 (Table 2).

Table 2. River basins' identified groundwater potential

Basin No	Basin name	Groundwater potential (hm³/year)
1	Meric – Ergene	507.7
2	Marmara	241.7
3	Susurluk	780.4
4	Northern Aegean	289.4
5	Gediz	1,155.9
6	Kucuk Menderes	179.2
7	Buyuk Menderes	1,045.4
8	Western Mediterranean	473.2
9	Antalya	1,164.7
10	Burdur Lake	106.4
11	Akarcay	345.4
12	Sakarya	2,197.1
13	Western Black Sea	641.2
14	Yesilirmak	907.2
15	Kizilirmak	2,003.1
16	Konya Closed	2,597.0
17	Eastern Mediterranean	96.5

Continuation of Table 2

18	Seyhan	838.8
19	Asi	393.2
20	Ceyhan	985.3
21	Euphrates-Tigris	4,994.8
22	Eastern Black Sea	490.9
23	Coruh	30.0
24	Aras	388.5
25	Van Lake	179.2
Total		23,032.3

The water budget of Türkiye encompasses various components such as precipitation, surface water, groundwater, and evapotranspiration (ET_a). In Table 4, the water balance components for major river basins, including infiltration are presented. Annually, Türkiye receives an average precipitation of 449.6× 10^9 m^3. Evapotranspiration accounts for 218.6 × 10^9 m^3, representing roughly 49% of the annual precipitation. The estimated total surface water potential stands at 180.8× 10^9 m^3, equivalent to about 40% of the precipitation, while groundwater recharge amounts to approximately 44.8× 10^9 m^3, constituting around 10% of the precipitation volume. Additionally, neighboring countries contribute an estimated 5.8 × 10^9 m^3 to surface water resources. Consequently, the gross water resources potential of Turkeie is calculated at 231.4× 10^9 /year m^3 as shown in Figure 3 (Harmancıoglu & Altınbilek, 2020).

Table 3. Water balance of Türkiye's basins

No	Basin name	Drainage area (km^2)	Million m^3			
			Precipitation	Flow	ET_a	Infiltration
1	Meric – Ergene	14,444.1	8,561.4	1,858.9	6,382.7	319.8
2	Marmara	23,107.1	16,186.8	7,537.9	8,405.5	243.4
3	Susurluk	24,332.0	15,645.1	4,227.2	8,776.5	2,641.4
4	Northern Aegean	9,973.6	6,051.4	1,500.5	3,969.0	581.8
5	Gediz	17,034.0	9,002.9	1,536.3	6,916.7	549.9
6	Kucuk Menderes	7,059.7	4,323.4	527.1	3,260.3	536.1
7	Buyuk Menderes	26,133.2	15,889.0	2,993.3	10,279.4	2,616.4
8	Western Mediterranean	21,223.9	15,705.5	6,965.1	7,458.6	1,281.7
9	Antalya	20,330.8	15,670.5	13,076.2	2,255.4	338.9
10	Burdur Lake	6,306.2	3,020.3	264.4	1,630.0	1,125.9
11	Akarcay	7,982.6	3,805.7	325.6	2,290.1	1,190
12	Sakarya	63,357.8	29,352.3	5,290.3	17,254.4	6,807.6
13	Western Black Sea	28,929.8	22,017.6	9,905.1	11,534.0	578.6
14	Yesilirmak	39,628.0	20,170.9	6,584.6	11,173.6	2,412.7
15	Kizilirmak	82,197.3	37,126.8	6,123.6	19,956.7	11,046.6
16	Konya Closed	50,037.8	19,524.8	2,649.7	11,294.3	5,580.7

Continuation of Table 3

17	Eastern Mediterranean	21,807.0	12,709.8	8,250.4	3,139.4	1,319.9
18	Seyhan	22,241.6	12,935.4	6,778.1	3,960.8	2,196.5
19	Asi	7,912.4	6,556.9	1,825.9	3,743.5	987.6
20	Ceyhan	21,598.5	14,025.6	7,349.4	6,338.1	338.0
21	Euphrates-Tigris	176,657	99,900.5	55,577.3	43,168.5	1,154.6
22	Eastern Black Sea	22,844.6	22,844.8	16,476.3	4,318.3	2,050.1
23	Coruh	20,248.7	14,286.0	7,047.1	5,858.3	1,380.6
24	Aras	28,114.6	13,593.2	4,182.2	8,370.2	1,040.8
25	Van Lake	17,977.0	9,164.3	2,263.2	6,823.7	77.4
	Total	78,1479.4	448,070.8	181,115.7	218,558	48,397

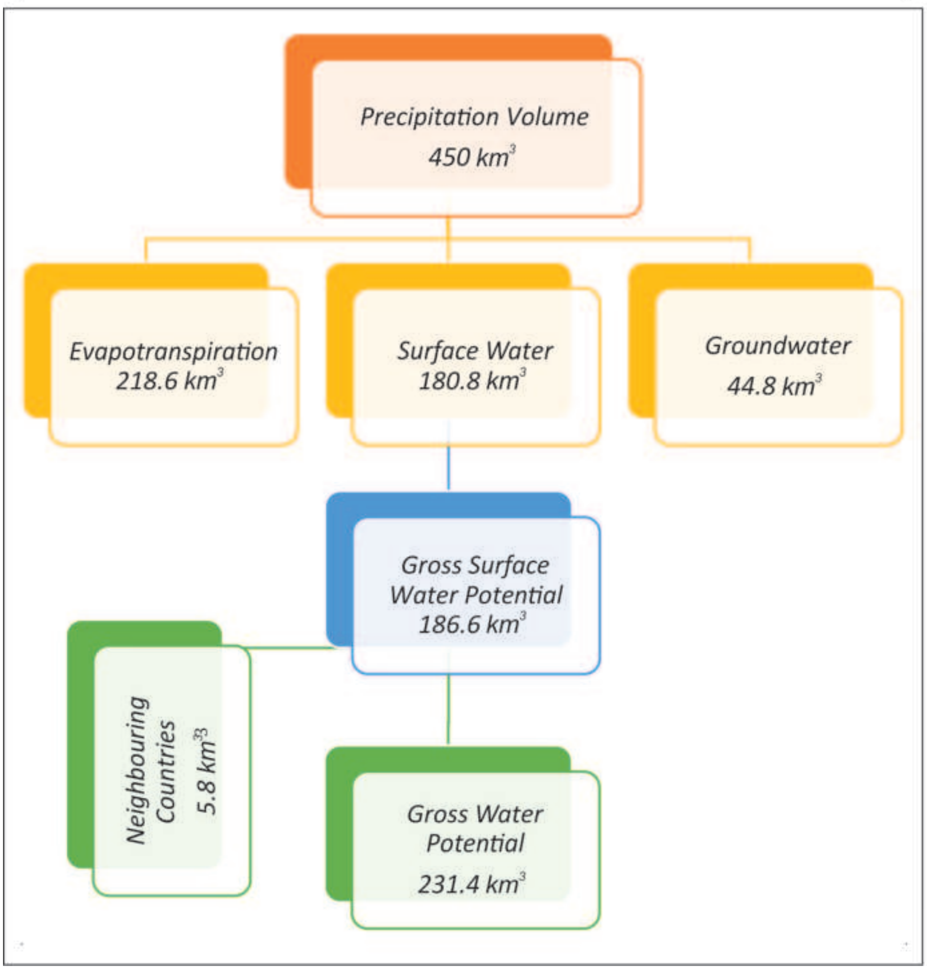


Figure 2. Türkiye's water budget and balance

Approximately half of the potentials mentioned above, comprising surface and groundwater, is discharged into seas and neighboring countries, rendering it unavailable for technical and economic utilization. Hence, the exploitable water resources of Türkiye are reported as $112\times10^9 m^3$ (Table 4) (DSI, 2024b).

Beside the rivers as water resources, 320 natural lakes have been identified in Türkiye by the Directorate General of Nature Conservation and National Parks. Some of these lakes are seasonal, replenishing with winter precipitation and diminishing during dry summer periods. Notably, among Türkiye's lakes, Lake Van (3,713 km^2), Lake Tuz (1,300 km^2), Lake Beyşehir (656 km^2), and Lake Eğirdir (482 km^2) stand out as the largest in size (DSI, 2024b).

There are four main regions in Türkiye, where lakes are concentrated as Lakes Region (Eğirdir, Burdur, Beyşehir, and Acıgöl), Southern Marmara (Sapanca, İznik, Uluabat, Kuş Gölleri), Lake Van and its surroundings, and Lake Tuz and its surroundings. Some lakes in Türkiye have depths exceeding 30 meters, while others are only a few meters deep. The average depth of Lake Van is more than 150 meters. The map of lakes in Türkiye according to their formations is provided in Figure 3 (Ministry of Forestry and Water Affairs, General Directorate of Water Management, 2017).

Figure 3. The lake map of Türkiye based on formations

Table 4. Water resources potential in Türkiye

Water balance indicators	**10^9 m^3**
Annual precipitation amount	450
Surface Water	
Annual surface runoff	186
Available surface water	94
Groundwater	

Continuation of Table 4

Annual withdrawable water amount	18
Total available water (net)	112
Development Status	
Irrigation water	44
Drinking water and industrial water	13
Total water usage	57

1.2. Water abstraction

The expansion of irrigated lands has gained significant momentum since the establishment of DSI in 1954 and TOPRAKSU in the 1960s. Instead of traditional irrigation methods, the development of irrigation systems for agricultural production has been significant; the area of irrigated land has increased by approximately 250% since the 1970s. Presently, out of the 28 million hectares of arable land, nearly 6.2 million hectares is irrigated through DSI projects, with a target to expand irrigated areas to 8.5 million hectares by 2023 (DSI, 2015). Since 2009, the Turkish government has incentivized the adoption of water-saving irrigation technologies by providing subsidies and interest-free loans to farmers. Currently, modern irrigation systems are particularly deployed in regions facing high climate vulnerability and water scarcity, such as the Konya Closed Basin. Water consumption per hectare exceeds 7,000 cubic meters (OECD, 2024).

Türkiye's agricultural sector predominantly produces cereals, dairy, livestock, vegetables, fruits, and non-food crops. The proportion of livestock in the overall agricultural output rose from 31% in 2000 to 47% in 2018, according to (OECD, 2024). From 2005 to 2016, livestock density experienced a remarkable 38% growth, significantly outpacing the OECD average increase of 8% (OECD, 2024).

Moreover, agriculture remains the primary user of abstracted freshwater, with the sector accounting for 74% of national water abstractions in 2018, slightly down from 75% in 2000. The percentage of irrigated areas also saw an increase, rising from 8% to 10% (OECD, 2024). Depending on the results of 2022, out of the total consumption of 57bln/m^3, 44bln/ m^3 (77%) water is used for irrigation for agriculture (MoAF, 2023 a).

The term "water footprint" is a relatively recent concept that offers a valuable framework for effective water management. It quantifies the volume of freshwater utilized in the production of goods or services, encompassing the entire lifecycle from raw material extraction to manufacturing processes, operational activities, and end-user consumption. As a result, it serves as an alternative metric for assessing water utilization, diverging from conventional water statistics which primarily focus on water withdrawals by considering consumptive water use instead (World Bank, 2016).

Water footprint estimations could give a sectoral water usage perspective as an alternative approach reimagining the understanding of water utilization across various sectors. Türkiye's total water footprint amounts to 140bln. m^3 per year. Of this, the agricultural sector accounts for 89%, domestic water use for 7%, and industrial production for 4%. More than 66% of the water utilized in plant production, a significant component of the agricultural sector, is green water. Grazing in this sector primarily contributes to green water consumption. These figures underscore the vital role of precipitation in the agricultural sector and highlight its vulnerability to drought conditions. About 20% of the water used in plant production is blue water, emphasizing the importance of irrigation methods and the efficient utilization of water resources in production processes (MoAF, 2023 a).

The relatively small portion of industry and domestic water supply within Türkiye's overall water footprint does not necessarily imply a minimal impact on water resources. While analyzing the water footprint of agriculture primarily considers green and blue water footprints (related to water quantity), assessing the water footprints of industrial production and domestic water supplies shifts focus to the grey water footprint, which indicates implications for water quality. Türkiye's water footprint of consumption totals approximately 140 × 10^9 m^3/year. Alternatively, this represents the total volume of freshwater utilized in the production of goods and services consumed within Türkiye (World Bank, 2016).

In Türkiye, The Turkish Statistical Institute collects data on water and wastewater statistics from several sources. These include manufacturing industry establishments with 50 or more employees, thermal power plants with an installed capacity of 100 MW or more, all organized industrial zone directorates that have completed their infrastructure, mining establishments that submit production data for the reference year to the General Directorate of Mining and Petroleum Affairs, and all municipalities.

In 2022, a total of 19.2 × 10^9 m^3 of water was abstracted from various water resources via various entities including municipalities, villages, manufacturing industry establishments, thermal power plants, organized industrial zones, and mining establishments. This marks an increase from the total water abstraction of 18.2bln/m^3 recorded in 2020 (Table 5) (TUIK, 2023).

Table 5. Amount of water abstracted from natural resources

Water abstracting sectors and resource type	(10^3 m^3)	
	2020	**2022**
Total amount of water abstracted	**18,238,294**	**19,233,935**
Amount of fresh water	8,021,131	8,313,148
Amount of fresh surface water (1)	3,916,376	4,058,364
Municipalities	3,574,184	3,628,431
Villages	3,544	3,463
Manufacturing industry establishments	175,386	242,758
Thermal power plants	78,852	86,981
Organized industrial zones	c	c
Mining establishments	c	c
Amount of fresh groundwater (2)	4,104,754	4,254,784
Municipalities	2,916,585	3,046,977

Continuation of Table 5

Villages	412,097	390,538
Manufacturing industry establishments	448,051	468,750
Thermal power plants	33,506	36,169
Organized industrial zones	129,704	135,334
Mining establishments	164,811	177,016
Marine water	10,217,163	10,920,787
Thermal power plants	8,165,292	8,757,539
Cooling water	7,663,966	8,234,817
Other	501,326	522,721
Manufacturing industry establishments	1,975,576	2,085,532
Cooling water	1,932,995	2,033,887
Other	42,581	51,644
Other (3)	76,295	77,717
Desalinated water amount	21,034	25,053
Amount of municipal wastewater reused after treatment	69,142	71,585

Retrieved from: TurkStat, Water and Wastewater Statistics, 2022;

Notes: Figures in table may not add up to totals due to rounding; c- Confidential data; (1) Includes water resources as river, lake, artificial lake, dam, etc.; (2) Includes water resources as well, spring, mine water, etc.; 3) Includes data of mining establishments, municipalities and OIZ.

In 2022, the distribution of fresh water abstraction from water resources among various entities like municipalities accounted for 80.3%, manufacturing industry establishments for 8.6%, villages for 4.7%, mining establishments and organized industrial zones for 4.9%, and thermal power plants for 1.5% of the total amount abstracted (Figure 5).

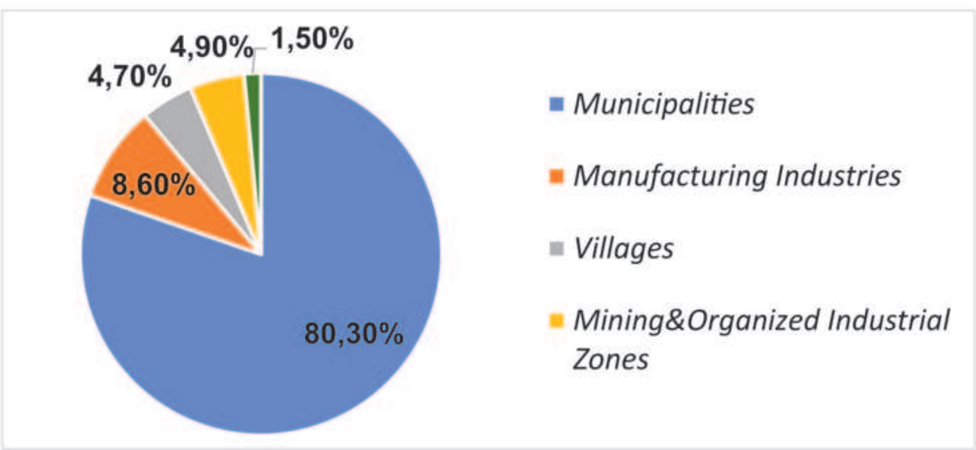


Figure 5. The distribution of freshwater abstraction from water resources among various entities

Municipalities abstracted a total of 6.7bln/m^3 of water from water resources (Table 7). Of this amount, 43% was abstracted from dams, 29.1% from wells, 16.5% from springs, 7.7%from rivers, and 3.7%from lakes, artificial lakes, or the sea.

Table 6. Municipal water supply indicators

Indicators	**2020**	**2022**
Türkiye population	83,614,362	85,279,553
Total number of municipalities	1,389	1,391
Total municipal population	78,920,614	80,785,141
Number of municipalities served by water supply network	1,387	1,390
Municipal population served by water supply network	77,915,139	79,830,591
Ratio of population served by water supply network in total municipal population (%)	99	99
Water abstraction for municipal water supply network (10^3 m^3/year)	6,492,402	6,676,197
Dam	2,658,335	2,869,119
Well	1,903,511	1,943,865
Spring	1,013,074	1,103,111
River	656,985	516,160
Lake-artificial Lake /sea (1)	260,497	243,941
Fresh surface water abstraction for municipal water supply network (thousand m^3/year)	3,575,817	3,629,220
Fresh ground water abstraction for municipal water supply network (thousand m^3/year)	2,916,585	3,046,977
Water abstraction per capita in municipalities (liters/capita-day)	228	229
Water distribution by municipal water supply network (thousand m^3/year)	4,309,405	4,568,750
Number of drinking water treatment plants	714	784
Physical	16	15
Conventional	220	243
Advanced	478	526
Total capacity of drinking water treatment plants (thousand m^3/year)	6,239,288	6,850,386
Physical	21,501	11,597
Conventional	5,668,930	6,073,387
Advanced	548,858	765,402
Amount of drinking water treated (thousand m^3/year)	3,900,478	4,061,607
Physical	9,160	1,018
Conventional	3,631,079	3,669,764

Continuation of Table 6

Advanced	260,240	390,825
Number of municipalities served by drinking water treatment plants	459	493
Municipal population served by drinking water treatment plants	48,381,682	50,650,358
Rate of population served by drinking water treatment plants in total municipal population (%)	61	63

(1) Water abstracted from the sea is included since 2010.

Of the total water abstracted in 2022, 56.8% came from the sea, while the remaining 43.2% was sourced from freshwater resources. Within this freshwater abstraction, 22.1% was from groundwater and 21.1% from surface water. It's worth noting that the primary purpose of 94% of the water abstracted from the sea was for cooling purposes. The difference between abstractions from different resources is given in Table ***7*** (TUIK, 2023).

Table 7. Amount of water supplied from water resources and water supply networks

Water abstracting sectors	Amount of water (10^3 m^3)					
	Total supplied water		Public water supply		Self and other supply	
	2020	2022	2020	2022	2020	2022
Manufacturing industry establishments	2,842,208	3,065,013	47,271	58,191	2,794,938	3,006,822
Thermal power plants	8,290,295	8,907,836	789	5,015	8,289,507	8,902,822
Mining establishments	282,981	291,233	3,531	3,443	279,449	287,790
Households	3,709,482	3,793,609	3,641,848	3,719,807	67,635	73,802

Note: Retrieved from: TurkStat, Water and Wastewater Statistics, 2022; Figures in the table may not add up to totals due to rounding.

The highest volume of abstracted water was seen in manufacture of basic metals and fabricated metal products and followed by manufacture of chemicals and manufacture of textiles and leather products (Table ***8***).

Table 8. Water statistics of manufacturing industry sub-sectors

Sub-sectors	Amount of water abstracted		Amount of water abstracted excluding cooling purpose	
	2020	2022	2020	2022
Manufacturing industry	**2,842 208**	**3,065,013**	**734,670**	**854,931**
Manufacturing of food, beverage, and tobacco products	163,245	220,130	143,199	196,989
Manufacture of textiles, wearing apparel and leather products	219,480	240,052	214,856	234,329
Manufacture of wood and of products of wood and cork (except furniture)	10,197	18,626	7, 881	9,237
Manufacture of pulp, paper and paper products and recorded media	35,712	40,121	35,480	38,977
Manufacture of coke, refined petroleum products	32,200	32,133	21,905	22,336
Manufacture of chemicals, chemical products, basic pharmaceutical products, rubber, and plastic products	493,407	485,641	125,489	135,304
Manufacture of other non-metallic mineral products	61,956	78,830	45,609	60,517
Manufacture of basic metals and fabricated metal products	1,790,262	1,909,274	106,316	118,858
Manufacture of computer, electronic and optical products, electrical equipment, machinery and equipment, motor vehicles, trailers and semitrailers and other transport equipment	30,242	33,940	28,481	32,203
Manufacture of furniture, other manufacturing, repair and installation of machinery and equipment	5,507	6,266	5,454	6,181
Source: TurkStat, Water and Wastewater Statistics, 2022.				
Manufacturing industry establishments' local units having 50 or more employees are covered.				
Figures in table may not add up to the totals due to rounding.				

1.3. Water user' structure: drinking water, agriculture, municipal water supply and sanitation; industry and others

Based on the results of 2022, out of the total consumption (Figure 6) of $57\times 10^9 m^3$, $44 \times 10^9 m^3$ (77%) are used for irrigation purposes, while $13 \times 10^9 m^3$ (23%) are used for drinking water (12%) and industrial (11%) purposes (DSI, 2024a). Approximately 71% of sectoral water usage is supplied from surface water sources, while 29% is sourced from groundwater. This value corresponds to 51% of the annual available water potential.

According to the results of the Address-Based Population Registration System in 2022, Türkiye's population is 84,980,000 people, with a population density of 109 person/km^2.

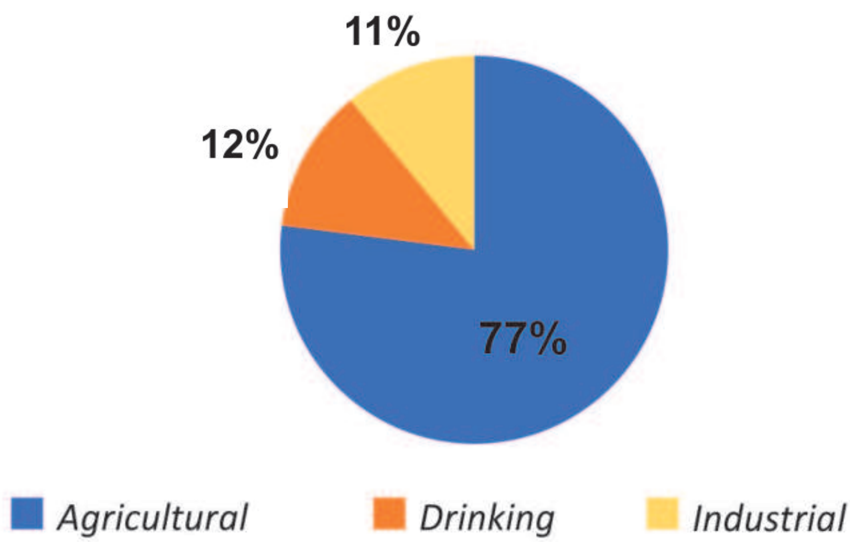


Figure 6. Sectoral water usage in Türkiye

The municipalities, villages, manufacturing industry establishments, thermal power plants, organized industrial zones, and mining establishments collectively discharged 16.4 × $10^9 m^3$ of wastewater into receiving bodies. Of this total, 76.5% was directed to the sea, 19.5% to rivers, 1% to dams, 0.8% to septic tanks, 0.7% to lakes and artificial lakes, 0.2% onto land, and 1.4%to other receiving bodies. Additionally, 80.2% of the wastewater discharged into the sea consisted of cooling water (TUIK, 2023).

Of the overall volume of wastewater discharged into receiving bodies, thermal power plants accounted for 52.4%, municipalities for 31.2%, manufacturing industry establishments for 12.9%, organized industrial zones for 1.7%, mining establishments for 1%, and villages for 0.7% (Figure 7).

Out of 1,391 municipalities, 1,390 are served by the water supply network. The ratio of the municipal population served by the water supply network, in relation to the total municipal population, is calculated as 98.8%.

Falkenmark water stress index indicates that when the per capita annual water supply in a country falls below 1700 m^3, it indicates a situation of seasonal or continuous water stress. When the water supply falls below 1000 m^3/per capita, it leads to difficulties in living conditions. If the water supply falls below 500 m^3/ per capita, serious challenges arise in human life, which is referred to as absolute water scarcity (Falkenmark et al., 1989). In Türkiye, the per capita available annual water supply was 1,652 m^3 in 2000,

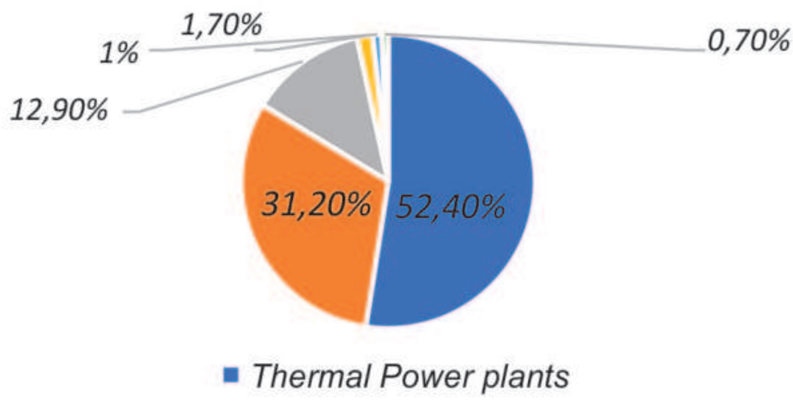


Figure 7. Wastewater discharge rates of water related sectors

1,544 m^3 in 2009, 1,346 m^3 in 2020 and 1,313 m^3 in 2022. Thus, per capita available water supply demonstrates that Türkiye is among the countries experiencing serious water stress.

Besides, when this indicator is estimated for the basin-based management purpose (Table 10), it can be seen that Burdur and Akarçay Closed Basins and also Gediz, Marmara and Kücük Menderes Basins have water potentials under 500 m^3/person/year (Atçı, 2020). The North Aegean, Asi, Susurluk and Sakarya Basins are grouped in the second risky category named as "water scarcity". Therefore, it is crucial to use water efficiently and optimally, and efforts are being made to utilize water resources in a multipurpose manner by building storage facilities. Additionally, measures are being taken to prevent water losses in irrigation operations, enabling more effective and efficient use of water, addressing drainage issues affecting soil quality through renovation projects, and promoting the widespread adoption of modern closed irrigation systems instead of traditional open irrigation networks.

In addition to efficient water usage, monitoring factors such as salinity, water quality, and soil analysis is crucial for the sustainability of agriculture. Conserving water and using it effectively are essential for ensuring food security, preserving ecosystems, and guaranteeing the sustainability of water resources for future generations. Therefore, promoting environmental awareness and collaboration for the conservation of water resources and improvement of agricultural usage are significant globally.

Table 10. Basin-based Falkenmark indicators

Basin Name	Falkenmark Indicator (m^3/person/year)	Evaluation
Çoruh	18,064	Water Richness (> 1,700)
Aras	5,610	
West Mediterranean	4,258	
East Black Sea	3,893	
Tigris-Euphrates	2,964	
East Mediterranean	2,748	
West Black Sea	2,706	
Ceyhan	2,367	
Antalya	2,104	
Seyhan	1,626	Water Stress (1,700 – 1,000)
Konya Closed	1,578	
Van Lake	1,505	
Büyük Menderes	1,263	
Yeşilırmak	1,139	
Kızılırmak	1,063	
Meric Ergene	1,014	
North Aegean	791	Water Scarcity (1,000 - 500)
Asi	769	
Susurluk	677	
Sakarya	555	
Gediz	497	Absolute Water Scarcity (500 >)
Akarçay	437	
Burdur Lake	244	
Marmara	161	
Küçük Menderes	109	

The municipalities have treated 60.8% of abstracted water. Out of the 6.7 bln/$m^3$of water abstracted from water resources to water supply networks, 4.1 billion/m^3 was treated in water treatment plants. Of this total, 90.4% was treated by conventional treatment methods, 9.6% by advanced methods, and 0.03% by physical methods (TUIK, 2023).

Sewerage systems provided service to 92.8% of the municipal population. Out of 1,391 municipalities, sewerage systems served 1,366 indicating that the ratio of municipal population served by sewerage systems in the total municipal population is 92.8% (TUIK, 2023).

Municipalities discharged a total of $5.4 \times 10^9 m^3$ of wastewater. Of this wastewater, 48.6% was discharged into rivers, 38.6% into the sea, 2.8% into dams, 1.9% into lakes and artificial lakes, 0.4% onto land, and 7.7% to other receiving bodies (TUIK, 2023).

Furthermore, 86.1% of the wastewater discharged were treated by municipalities. Out of the $5.4 \times 10^9 m^3$ of wastewater discharged from sewerage systems, $4.6 \times 10^9 m^3$ treated in wastewater treatment plants. Among this treated wastewater, 52.7% by advanced treatment, 25.2% by biological treatment, 21.7% by physical treatment, and 0.4%by natural treatment (TUIK, 2023).

CHAPTER 2. WATER SECTOR INSTITUTIONAL FRAMEWORK

2.1. Existing legal framework

In the Republic of Türkiye, it is stated in the Constitution as a basic provision that water resources are the natural wealth of the country and that they shall be used for the benefit of the people under the management of the state. In this framework, the Constitution evaluates water resources in two categories as common and private use. The development of water resources, including groundwater, is under the responsibility of the state, except for small resources owned by private individuals (USIAD, 2011).

Various public and private sector organizations are directly and indirectly involved in the development and protection of water resources in Türkiye. In the institutional framework, this structure consists of three stages: national, provincial and local (municipalities and villages). In this process, The Ministry of Agriculture and Forestry, The Ministry of Energy and Natural Resources, The Ministry of Environment, Urbanization and Climate Change, The Ministry of Culture and Tourism, The Ministry of Health, The Ministry of Internal Affairs and The Ministry of Foreign Affairs are involved in decision-making mechanisms. The institutions like General Directorate of State Hydraulic Works (DSİ), General Directorate of Meteorology, General Directorate of Mineral Research and Exploration, General Directorate of The Ilbank and similar organizations are involved in management and development; and farmers, Water User Associations and other water consumers are involved in utilization phase (Avcı, 2021) (Figure 8).

The main sources of the law of the Republic of Türkiye are the constitution, laws, decrees with the force of law, international treaties, statutes, and regulations. In Türkiye, there are many laws and decrees with the force of law on the development and management of water resources within the framework of the duties, powers and responsibilities of the institutions, and there are many regulations, communiqués and circulars regulating their implementation (GoT, 2018).

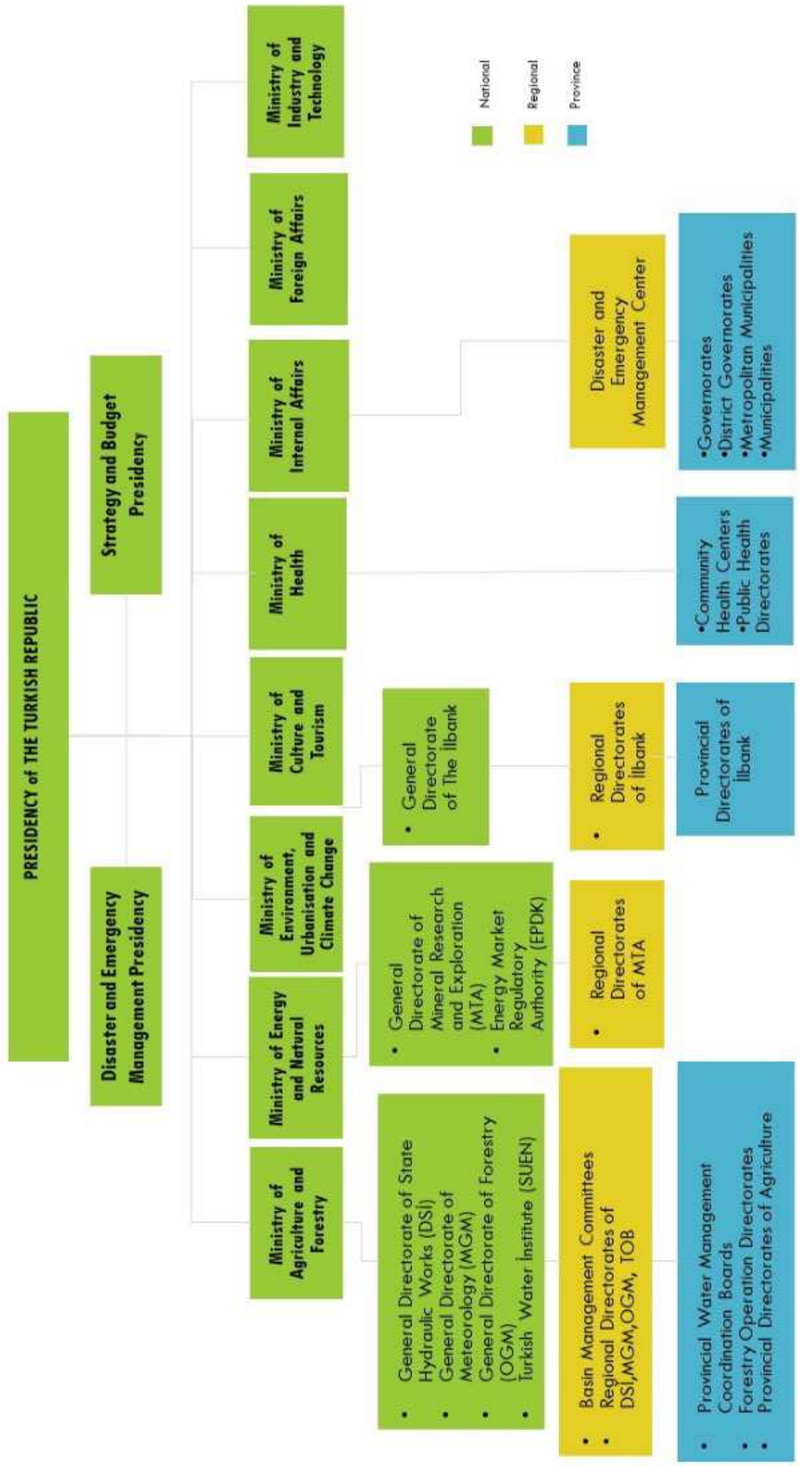


Figure 8. The institutional framework of "water management" in Turkiye

Main legal regulations related to water (GoT, 2018) in chronological order are as follow:

- Village Law, no. 442,1924 (Articles 1, 6 and 13)
- Law on Waters, number 831,1926
- Law on Public Hygiene, number 1593,1930
- Law on the Organization and Duties of the Bank of Provinces (abrogated), no. 4,759, 1945 (instead of the Municipalities Law No. 2,301 of 1933)
- On the Organization and Duties of the General Directorate of State Hydraulic Works Law, number 6,200, 1953
- Village Drinking Water Law, number 7,478, 1960
- Law on Groundwater, No. 167, 1960
- No. 1053, to DSİ for Ankara, Istanbul and Cities with a Population Larger than 100,000 Act Authorizing the Supply of Drinking Water, 1968
- Environmental Law, number 2,872, 1983
- Decree Law on the Organization and Duties of the Ministry of Health Decree, no. 181, 1983
- Law on the Establishment and Duties of the General Directorate of Agricultural Reform, number 3,155 (Article 2/c), 1985
- Law on the Organization and Duties of the General Directorate of Rural Services, number 3,202 (KHGM) (Article 2/d), 1985 (repealed)
- Law No. 3,416 amending the Environmental Law No. 2872, 1988
- Coastal Law, number 3,621, 1990
- Decree Law on the Establishment and Duties of the Ministry of Environment Decree, No. 443, 1991 (repealed)
- Law on the Establishment and Duties of the Ministry of Agriculture and Rural Affairs Decree Law, no. 441, 1991
- Law No. 4950 amending the Law No. 1380 (1971) on Fisheries, 2003
- Municipal Law, no. 5393, 2005 (Municipal Law no. 1580 (repealed), 1930; Municipal Law No. 5215 (repealed), 2004
- Law no. 3030 (1984) on Metropolitan Municipalities, which replaced the Law no. 5216, 2004
- No. 2560 Establishment of Istanbul Water and Sewerage Administration General Directorate Law on Duties, 1981
- On the Abolition of the General Directorate of Village Services (KHGM) Law, 2005
- Law on Special Provincial Administration, number 5302, 2005
- As a result of the amendment of Article 10 of Law No. 1053, the population criterion and all settlements with a municipality organization will be abolished, and the drinking, utility and industrial water supply systems of all settlements with a municipality organization will be abolished authorizing DSİ for the construction of water and, if necessary, wastewater facilities 5625 Law No, 2007
- Law on Geothermal Resources and Natural Mineral Waters, number 5686, 2007
- Law on the Organization and Duties of the Ministry of Environment and Urbanization Decree Law, no. 644, 2011

• Law on the Organization and Duties of the Ministry of Forestry and Water Affairs Decree Law, no. 645, 2011

• Decree Law on the Establishment and Duties of the Turkish Water Institute Decree, no. 658, 2011

Thus, Türkiye's current water legislation defines legal status of water resources, the principles of water usage, protection, transboundary water management and all aspects of the water governance. The country continues updating the national legislative framework within the country's current policies, arisen from climate change, as well as framework of the current EU directives. Comprehensive reforms related to institutional and legal issues have been gradually taking place with the objective of meeting the targeted strategies for better water management under its scarcity.

2.2. The governance of the water resource management – institutional structure

Türkiye is currently recognized as a country struggling with "water stress" and has a semi-arid climate. In light of the compounded challenges posed by climate change, effective water management has emerged as a critically significant concern for Türkiye. Besides, insufficient water resource availability, the rise in water demand driven by rapid population growth, expanding water needs in industrial and agricultural sectors, declining groundwater reservoirs, and the negative effects of water pollution, all underscore the critical need for basin-scale water resources management.

Türkiye has initiated harmonizing its laws with the European Union (EU) legislation since its candidate country procedures for the EU membership. It is necessary to ensure certain harmonization requirements in the process of Türkiye's accession to the EU. One of these is the issue of 'Water Assets', one of the sub-headings within the 'Environment Chapter' officially opened on 21 December 2009. What needs to be done in this context is to make the necessary changes at both national and international levels in line with the 'EU Water Framework Directive' adopted by the EU on 23 October 2000. Here, is what is expected from our country regarding water assets and management. One of the steps is to harmonize the existing legislation on water with this directive and the other is to establish River Basin Management Plans (RBMP) for the river basin regions. The RBMP consists of the following stages: determination of the characteristics of the basins to be planned, identification of the problems and pressures, determination of the areas to be protected, mapping, preparation of the program of measures to be taken, implementation of these measures with the participation of the public, and finally monitoring the implementation and making changes (GoT, 2018).

The Directive consists of 8 main provisions, namely designation of basins, analysis and monitoring of waters, environmental objectives, measures to be taken, management plans, administrative measures, cost recovery and public participation.

The main objective of the Water Framework Directive is to establish a framework for the protection of inland surface waters, transitional waters, coastal waters and groundwater (Kücükcelebi, 2014). The Water Framework Directive also introduces a new approach to protect and sets a target for the improvement of all water bodies, water management based on river basins prevents political demarcation of water systems; introduces a holistic approach to emission limit values and quality standards; requires cross-border work between relevant countries and institutions, a participatory approach involving all institutions, non-governmental organizations and the public in water management; reduction and control of agricultural, industrial, domestic and all other sources of pollution; water charging and the obligation of the polluter to pay; balance the relationship of those who depend on the environment (Akkaya et. al., 2006)

The most important of the new elements introduced by the Directive is integrated river basin management. Basin boundaries will be demarcated and managed according to the natural boundaries of the river and not according to political boundaries. In the case of river basins involving more than one Member State, they will be linked to an 'international river basin district' and a competent authority will be appointed. The Directive envisages three stages of planning, including analyzing the characteristics of each catchment area, determining protection measures and establishing River Basin Management Plans. One of the basic principles advocated by the Water Framework Directive is application of the polluter pays principle (Kibaroglu et.al., 2006).

Basin Management Committees (BMCs) and Provincial Water Management Coordination Committees (PWMCs) meetings were held in 81 provinces in 25 river basins of Türkiye, under the chairmanship of Coordinator Governors with the participation of members of relevant institutions and organizations. As of 2016, to prepare River Basin Management Plans (RBMP) in the country, studies were carried out with all stakeholders to ensure integration with the upper plans. To evaluate natural resource (forest, pasture, etc.) plans that will positively affect the quality and quantity of water resources on a basin basis within the scope of management plans, studies have been carried out to ensure the harmonization of RBMPs with natural resource plans (GoT, 2018). Besides, sectoral water allocation is essential in basin-based water management. In this context, water allocation projects are ongoing (TAGEM,2021).

Within the scope of the European Green Deal, which was announced on 11 December 2019, Türkiye has prepared the Türkiye's Green Deal Action Plan consisting of nine main topics. Under the heading of 'A Green and Circular Economy', action plan included (i) reuse of treated wastewater, (ii) preparation of 'Water Reuse National Master Plan' and (iii) preparation of a 'guidance document on water footprint' in the light of sectoral Water Allocation Plans (MoAF, 2023 a) .

There is a study planned to be implemented on the enactment of a holistic 'Water Law' covering the social, economic and technical dimensions of water assets in our country and draft studies have also been carried out on this subject. The purpose of this draft, which has been prepared comprehensively, is to ensure the sustainable protection and utilization of water resources, basin plans and allocations by determining the priorities of utilization from a single authority. This draft is expected to be compared with the issues required by the Water Framework Directive and to be finalized in case of any deficiencies.

In 2019, a 'National Water Plan' was prepared to guide the formulation and implementation of the national water policy in line with the current situation and potential of water resources. This guide has been prepared to take the first steps to ensure basin-based water management, to protect and increase the efficiency of water resources from 2019 – 2023. One of the frequently repeated warnings in the National Water Plan is that the draft water law should be finalized and put into force as soon as possible. Many of the directions in the Plan are in parallel with the Water Law and Water Framework Directive.

In this context, the necessity of enacting this law was also evaluated within the scope of the '1st Water Council' held on 4th October 2021, and it was decided to enact it as soon as possible in the final declaration of the Council (MoAF, 2021b).

2.3. Functionality of the main agencies involved into the water sector governance

One of the main works to be done within the scope of harmonization with the Directive is to review the existing legislation on water management, to eliminate overlapping points, and to make the necessary legal arrangements for this purpose. These legal arrangements may be in the form of rearranging the duties and authorities of the institutions given by their founding laws to eliminate overlapping points, or in addition to this, new laws may be prepared (Akkaya et. al., 2006).

Türkiye's 8th (2001 – 2005) and 9th (2007 – 2013) National Development Plans included some targets related to water management. Based on the 10th National Development Plan (2014 – 2018), the 'Action Plan for the Effective Use of Water in Agriculture' aims to establish centralized monitoring facilities for water storage and irrigation networks. In this context, the installation of electronic measurement facilities with central monitoring has been initiated in the storage facilities and irrigation networks within the responsibility area of the General Directorate of State Hydraulic Works. Installations are made in such a way that measurements can be made on water user unit basis (TAGEM, 2021).

Since 2016, the GDWM has started to implement 'Sectoral Water Allocation Plans' to regulate water use, taking into account economic, social and environmental benefits. River Basin Management Plans are prepared to protect and minimize the negative impacts of pressures on water bodies by both identifying pressures and defining measures (TAGEM, 2021).

Besides this, with the "Presidential Decree on the Organization of the Presidency" dated 10.07.2018, No1 (Official Gazette 10/7/2018-30474), "to carry out studies to establish policies on the protection and sustainable use of water resources" and "on the impact of climate change on water resources to carry out studies" has been assigned to the GDWM. In this direction, the "Water Efficiency Strategy Document and Action Plan within the Framework of Adaptation to a Changing Climate" has been prepared in which future targets and strategies are determined to promote water efficiency in all sectors of our country (MoAF, 2023 a).

The urban water efficiency axis is analyzed through water supply and water uses at the urban scale and individual water uses in households. The urban water efficiency approach includes water efficiency in drinking and potable water systems and individual water efficiency; water use in institutions and organizations at an urban scale (tourism, public, service sector, etc.), water withdrawal from the source, treatment, transmission to the network, consumption by users, treatment of wastewater, reuse of treated water and pricing to encourage efficient use of water. The basic principle in water supply is the timely delivery of quality and desired amount of water to the users. For this reason, it is extremely important to prevent water losses, minimize failures and ensure operational efficiency at every stage from the source to the end user. Preventing and controlling the losses, especially in the networks of municipalities, will contribute to the postponement of the search for new resources and more efficient use of existing resources. The water loss rate in drinking water supply and distribution systems in 2021 was calculated as 33.54%. In line with the target of reducing the rate of water losses in all municipalities to 25% by 2033 and 10% by 2040 as required by the legislation, strategies and actions for the implementation of studies to increase the efficient use of water are set out in the Document (MoAF, 2023 a).

The 11th National Development Plan (2019 - 2023) aims to increase improvements in water use efficiency, accelerate institutional arrangements and increase investment in irrigation infrastructure. In addition, basin-based planning for the reuse of treated wastewater, especially in agriculture, and reducing the pressure on water resources have been identified as policies and measures. The National Water Plan (2019 - 2023) basically aims to ensure efficient, rational and sustainable use of existing water resources before new water resources are found and made available to users (TAGEM, 2021).

Efficient use of water in agricultural irrigation, which constitutes a significant portion of sectoral water use, will bring about significant water savings. Agricultural irrigation efficiency represents the ratio of total plant irrigation water requirement to the amount of water taken from the water source to the network. According to 2021 data, the irrigation efficiency value in irrigation systems operated and transferred by the DSI is calculated as approximately 50.4%. Within the scope of the Water Efficiency Strategy Document, it is aimed to increase the irrigation efficiency to 60% by 2030 and 65% by 2050. Based on these targets, strategies and actions have been identified for the dissemination of practices that increase agricultural irrigation efficiency (MoAF, 2023 a).

Different training programs on modern irrigation techniques are implemented in training activities carried out in training centers and Provincial Directorates of the Ministry. In extension activities, farmers are trained on the use of solar energy systems in drip irrigation, water harvesting techniques and irrigation. In this way, universities, research institutions and educational institutions are provided with the opportunity to see the applications of subsoil drip irrigation systems, irrigation techniques in greenhouses, automatic irrigation systems and closed drainage systems on site. For this purpose, study tours are organized to universities, research institutions and organizations, training centers and facilities of companies producing irrigation equipment, workshops, conferences, field days and demonstration activities are carried out (TAGEM, 2021).

In order to visually support the activities, extension materials on automatic irrigation systems, the use of domestic wastewater in irrigation, irrigation in greenhouses, water harvesting, the use of renewable energy sources in irrigation, digitalization and irrigation, subsoil drip irrigation, leaching irrigation and the damages of excessive irrigation were designed and distributed to farmers. For the training and extension activities carried out, various training and broadcasting platforms were created where different applications were put into service, and various digital portals were designed to ensure that farmers and other target audiences can access the information they need at any time. The "Agriculture and Forestry Academy" portal, designed as a distance education model by the Directorate of Education and Publishing, delivers the information needed by target audiences through educational videos on the internet (TAGEM, 2021).

There is another institution named Turkish Water Institute (SUEN) that is a special funded entity under the authority of the MoAF. SUEN is a think tank that aims to develop short and long term strategies, as well as national policies to achieve better water governance. SUEN works in cooperation with national and international water-related institutions on issues such as sustainable water management, developing water policies, sustainable energy and capacity building for solving local and global water problems (SUEN, 2024). To contribute to the development of opportunities and tools necessary for the development of sustainable water policies and strategies for solving global water issues, to conduct and support scientific research in order to develop national and international water policies, to contribute to international forums, conferences, meetings, seminars, symposiums and similar activities, to organize training programs at national and international level, to cooperate with foreign institutions and organizations. (GoT, 2018).

In addition to public institutions, two institutes have been established within the universities focusing on water management. Ankara University Water Management Institute (ENSTİTUSU) and Suleyman Demirel University Water Institute were established on 01.02.2010, by the decision of the Council of Ministers numbered 2010/10[3], pursuant to Additional Article 30 of Law No. 2809 dated 28.03.1983 (Su Enstitüsü, 2024). In this context, ENSTİTUSU aims to carry out research, graduate education and societal contribution activities in water resources management by focusing on sustainability and sectoral water efficiency; to develop policies for water security and to play a leader role in the field of water management in local, national and international scale (ENSTİTUSU, 2024). Research areas of ENSTİTUSU are climate change and water risks, water and food security, sustainable environmental and water management, agricultural, industrial and urban water efficiency, alternative water sources, virtual water trade, circular economy and resource recovery, life cycle, water and carbon footprint analysis, national and international water law. Eleven projects have been completed in total; of which five projects were funded via international grants like European Union, UNDP and British Council (ENSTİTUSU, 2024).

Suleyman Demirel University Water Institute aims to make rational definitions in line with the development goal with the projects and postgraduate studies to be carried out in order to leave healthy and sufficient water to future generations in Türkiye and primarily in the Lake Region (ENSTİTUSU, 2024).

CHAPTER 3. CLIMATE CHANGE AND WATER MANAGEMENT

3.1. Agricultural water use - irrigation, crop pattern, infrastructure

Climate change significantly impacts water resources globally, affecting their quantity, quality, and availability. The rise in temperature, changes in precipitation patterns, and extreme weather events associated with climate change alter the water cycle and significantly impact water resources (Ray et al., 2023). These changes include alterations in the distribution of water resources, increased melting of glaciers, enhanced evaporation, and shifts in water availability, all of which have implications for water quantity and quality. Studies have shown that climate change is affecting the sustainability and management of water resources, with implications for human health, food production, and ecosystem stability (Roeger & Tavares, 2021). The impacts of climate change on water resources encompass changes in water supply and demand balance, vulnerability to drought, and the sustainability of water systems. Additionally, the effects of climate change on water resources extend to groundwater availability, streamflow patterns, and freshwater ecosystems, with most regions expected to experience a net negative impact (Xia et al., 2004).

Climate change is a significant global issue that is impacting various sectors, including agriculture. Agricultural activities depend on natural resources such as temperature, precipitation, atmospheric carbon dioxide, and extreme weather events. Soil conditions are also vital for healthy plant growth. Climate change impacts agriculture by altering temperature and precipitation, increasing extreme weather events, reducing water resources, and worsening droughts. These changes lead to more pests and diseases, ecosystem degradation, and loss of biodiversity and fertile soils (Ministry of Agriculture and Forestry, 2022). Consequently, there are shifts in plant growth periods, decreased product quality, higher production costs, and reduced livestock production efficiency. These changes are expected to affect agricultural practices such as disaster response, pest control, fertilizer application, and species selection. The response of agricultural water use to climate change and plantation structures plays a crucial role in determining future water requirements for irrigation (Wang et al., 2022).

The altered meteorological events resulting from climate change can lead to population displacement, declining food productivity, and vulnerabilities in agro-ecosystems, necessitating adaptive strategies to enhance resilience in agricultural infrastructure (Dash, 2024).

Additionally, the impact of climate change on crop and livestock productivity underscores the need for effective adaptation measures to mitigate negative effects on agricultural practices.

The agricultural sector holds a significant share in Türkiye. The country's agricultural lands are grouped into categories such as fruit, beverage, and spice crops, fallow land, vegetables, ornamental plants, and cereals-other crop areas. In 2023, cereal production quantities were approximately 42.2 million tons. Wheat production was 22 million tons, barley – 9.2 million tons, rye production - 305 thousand tons, and oat production - 410 thousand tons. In 2023, there was a 23.6% decrease in cotton production compared to the previous year. Lint cotton production dropped from 2.75 to 2.1 million tons. However, sugar beet production increased by 22.1% during the same period, rising from 19.2 million to a provisional figure of 23.5 million tons. Tobacco production also saw a provisional increase of 4%, growing from 82.25 tons to 85.51 tons. Potato production experienced a 9.6% increase, rising from 5.2 to 5.7 million tons. Additionally, vegetable production amounted to 31.78 million tons, while fruit production reached 27.41 million tons. (TUIK, 2024).

Water footprint analyses reveal that agriculture constitutes the largest share of water usage in Türkiye, accounting for 89% of the water footprint of production, with domestic use at 7% and industrial use at 4%. Within agriculture, 92% of the water footprint comes from crop production, while grazing contributes 8%. Cereal crops dominate the water footprint of crop production at 38%, followed by forage crops (32%), fruits/nuts (13%), industrial crops (10%), oil crops (5%), and vegetables/legumes (2%) (WWF, 2014). Approximately 85% of Türkiye's arable land is used for rain-fed agriculture. Analyses show that 64% of the agricultural water footprint in Türkiye is green water, derived from rainwater used during production, while 19% is blue water, sourced from surface and groundwater (WWF, 2014). These findings underscore the significant role of rainwater in Turkish agriculture, where yield per unit area in rain-fed conditions varies widely depending on rainfall levels.

Climate change-induced drought significantly impacts agricultural activities in Türkiye, particularly affecting the production of cereals, legumes, and fodder crops (MoAF, 2021a). In recent years, drought has emerged as a major issue affecting agricultural production across the country. The drought has affected 41 provinces in Türkiye. It is reported that during the production season from October to April, rainfall decreased by 23.6% compared to normal levels and by 18.6% compared to previous years. Barley and wheat were among the crops severely affected by drought during this period, with wheat alone experiencing a yield loss of 2 million tons due to drought (MoAF, 2022).

Climate change-induced temperature rise leads to yield losses in certain crops. Excessive temperature increases directly cause yield reductions in rainfed agricultural regions, while in irrigated areas, despite adequate watering, plants suffer from heat stress, resulting in decreased yields. Changes in rainfall, temperature, and radiation affect the phenological stages of plants, advancing harvest dates. This shorter growth period implies negative impacts on product quality and yield in crops, such as grain filling, number of grains per spike, and grain weight. Fruit trees face increased risks of late frosts due to early flowering, leading to premature fruit ripening and deterioration in fruit quality. Overall, rising temperatures across Türkiye are observed to affect the phenological stages, productivity, and production of plants.

In Türkiye, during the period from 2010 to 2021, the most frequent meteorological natural disasters were storms, heavy rainfall/floods, and hailstorms (TSMS, 2021). Natural disasters and extreme events such as storms, floods, and hailstorms pose significant challenges to agriculture, causing extensive damage to crops, orchards, and greenhouses. Additionally, extreme weather events can lead to soil erosion, nutrient loss, and long-term degradation of agricultural land. As climate change progresses, the frequency and intensity of these natural disasters are expected to increase, further threatening food security and the livelihoods of those dependent on agriculture. To mitigate these impacts, it is crucial to develop resilient agricultural practices, invest in disaster preparedness, and enhance early warning systems (Sivakumar et al., 2005).

In Türkiye, the fundamental policies of relevant authorities aim to achieve several goals: enhancing quality, production, and trade; ensuring supply security; protecting public health and consumer interests; boosting the competitiveness of the food, agriculture, and forestry sectors; efficiently utilizing ecological resources; implementing measures to address climate change and its impacts; and conducting necessary studies in these areas (MoAF, 2022). In this context, the Ministry of Agriculture and Forestry's Strategy Action Plan (2018 - 2022) outlines responsibilities such as implementing services related to drought, agricultural environment, desertification, other agricultural disasters, and agricultural insurance; and providing assistance to farmers affected by natural disasters in accordance with the principles specified in special legislation.

The 11th Development Plan of Türkiye, defined specific goals directly related to climate change. Some of these goals include preparing action plans to combat invasive species and agricultural pathogens related to climate change, developing scenarios for changing crop patterns to adapt to climate change, and supporting innovative and environmentally friendly production techniques, particularly smart agriculture technologies (GoT, 2018).

Besides, The Ministry of Agriculture and Forestry in Türkiye implemented the "Türkiye Agricultural Drought Management Strategy and Action Plan" after the drought in 2007. The action plan aimed to initiate pre-planning necessary for achieving sustainable land, soil-water, and plant management to enhance the agriculture sector's capacity to adapt to climate change and ensure access to safe food over a five-year period. Topics included planning irrigation and necessary water investments in dry and irrigated agricultural areas, climate-friendly farming techniques, plant and seed diversity, irrigation methods, pest and disease control, economic and social support, pasture grazing plans, land use plans, and implementation of emergency actions, among others, in line with decisions and practices set by the administration (MoAF, 2022).

Türkiye's National Climate Change Adaptation Strategy and Action Plan targets key sectors like water management, agriculture, and food security, supported by scientific studies. It outlines five priority goals for agriculture: integrating climate adaptation into policies, enhancing research, sustainable water use, protecting soil and biodiversity, and improving institutional capacity and cooperation. The plan aims to develop integrated low-carbon, climate-resilient agricultural systems to ensure sustainable food security and ecosystem health. Key methods include climate-smart agriculture, efficient irrigation practices, soil moisture conservation, and reducing CO_2 emissions through practices like reduced tillage. Direct seeding and windbreaks are also promoted to combat soil erosion. Effective fertilization techniques, such as using animal manure and slow-release fertilizers, are crucial for adaptation and mitigation. (MoAF, 2021a).

Efforts to address the impacts of climate change on agricultural water use emphasize the importance of incorporating efficient irrigation management practices and climate-adaptive agronomic strategies. Establishing effective agricultural water management strategies is crucial for enhancing preparedness and capacity to respond to the challenges posed by climate change and human interventions (Kourgialas, 2021). Furthermore, the role of irrigation in mitigating the adverse effects of climate change on agriculture is highlighted, with irrigation being a key adaptation measure to reduce the impacts of changing climatic conditions on farming.

Climate change-induced phenomena such as rising temperatures, altered precipitation patterns, extreme weather events, and shifts in pest dynamics pose significant threats to crop yields and agricultural productivity. These changes necessitate the development of sustainable agricultural practices, including organic farming, to enhance crop resilience and adaptability to changing climatic conditions. Moreover, the impact of climate change on water resources availability and agricultural water demand underscores the need for effective water management policies to address water scarcity and ensure sustainable agricultural practices (Mizyed, 2008; Yazdi et al., 2022).

In conclusion, in Türkiye, climate change is profoundly impacting water resources, agricultural water use, irrigation practices, crop patterns, and infrastructure, altering their quantity, quality, and sustainability. The complex interplay between climate change and these vital systems necessitates comprehensive assessments, adaptive management strategies, and sustainable practices to address the evolving challenges and ensure resilience. Efforts to assess the impacts of climate change on water resources involve modeling protocols, vulnerability assessments, and adaptive management strategies aimed at understanding the intricate interactions between climate change and water resources. These approaches aim to develop sustainable water supply systems and enhance resilience to future climate scenarios. Similarly, addressing the challenges posed by climate change in agriculture requires a holistic approach that integrates efficient water management practices, climate-resilient crop cultivation, and adaptive infrastructure development. By implementing climate-smart agricultural practices and sustainable water resource management strategies, stakeholders can mitigate risks and ensure the long-term sustainability of both water and agricultural systems. These targeted adaptation measures are essential for securing food security, environmental sustainability, and the overall resilience of agricultural and water systems in the face of a changing climate.

3.2. Water supply and sanitation – consumers and infrastructure

The construction of channels for rainwater in India and the use of large trenches for the removal of wastewater in Babylon and Egypt highlight that the issue of access to clean, reliable, and adequate water has been one of the most important engineering activities since ancient times (Erdin, 2001). Today, water collected from various sources for human consumption is transported to reservoirs via transmission lines and then delivered to users through networks. This process, from collecting water at its source to delivering it to users, is vital for urban life (Dilcan Coşkun et al., 2018). Approximately 4 billion people or nearly two-thirds of the world's population, experience severe water scarcity for at least one month each year (Mekonnen & Hoekstra, 2016). According to the United Nations' 2023 Goal 6: Clean Water and Sanitation report, since 2015, the global population with access to safely managed drinking water services has increased by 687 million people. However, despite this progress, in 2022, 2.2 billion people worldwide still lacked access to safely managed drinking water services, and 703 million people did not have basic water services. Between 2015 and 2022, the rural population without access to safely managed drinking water decreased from 1.5 billion to 1.3 billion, while in urban areas, this number increased from 784 million to 857 million Despite progress, 1.9 billion people globally still do not have basic hand-washing facilities with soap and water at home, including 653 million people who have no hand-washing facilities at all (UN, 2023a; UN, 2023b). Urban water systems are increasingly vulnerable to climate change effects, such as altered precipitation patterns, more frequent and intense extreme weather events, and shifts in water availability and quality (Nwokediegwu, 2024). Factors such as marginalization, inequality, and inadequate infrastructure in rural areas and small towns exacerbate the vulnerability of water supply and sanitation systems to climate change (Abrams et al., 2021). The impacts of climate change on sanitation infrastructure can lead to the spread of diseases when extreme weather events damage facilities and limit access to sanitation services (Murungu et al., 2022).

The effects of urban development patterns on municipal water shortage highlight the need for sustainable water management practices to address future water demand and reduce vulnerabilities in water supply systems (Heidari et al., 2021).

Efforts to achieve Sustainable Development Goal 6, which focuses on clean water and sanitation, are at risk due to the adverse effects of climate change on water supply systems (Becher et al., 2023). The resilience of water supply infrastructure becomes increasingly crucial as climate change threatens to impede progress towards universal access to safely managed sanitation services (Hyde-Smith et al., 2022). Moreover, the interplay of environmental virology, public health, and sanitation underscores the intricate relationship between climate change and the provision of water and sanitation services (Opere, 2023).

Efficient management of water resources in urban areas is crucial, especially considering the escalating urban enlarging and the impact of climate change on precipitation patterns (Piazzi et al., 2021). The future scenarios modeling of urban stormwater management responses to climate change and urbanization underscores the importance of proactive planning to address the evolving challenges in urban water systems (Wang et al., 2017). In the face of climate change, the need for resilient water supply infrastructure is paramount to ensure the sustainability of water resources and sanitation services (Becher et al., 2023). The impacts of climate change on water supply and sanitation extend beyond physical infrastructure to encompass broader challenges related to water stress, water-transmitted diseases, and inequalities in access to water, sanitation and hygiene services (Kohlitz et al., 2017). As climate change continues to unfold, there is a growing recognition of the necessity to assess existing infrastructural vulnerabilities and develop adaptation strategies to safeguard urban water and sanitation services (Clemenz et al., 2019).

In Türkiye, sanitation infrastructure includes wastewater treatment plants, sewer networks, and waste disposal systems. Urban areas are well-served with extensive sewer networks and wastewater treatment facilities. However, rural areas still face challenges in achieving adequate sanitation coverage. The government has implemented several initiatives and policies to address water supply and sanitation challenges. Key programs focus on infrastructure investment, regulation and standards, and public awareness. By addressing these challenges, public health, environmental sustainability, and the quality of life for its citizens could be improved.

Losses in drinking water transmission lines can be defined as the difference between the amount of water supplied to the drinking water line and the amount of water legally consumed by users. Water losses in drinking and utility water transmission lines are divided into two groups: physical water losses and administrative water losses. The sum of these two losses is referred to as the total water loss (WHO&UNICEF, 2000).

Generally, approximately 60% of total water losses consist of physical water losses, and about 40% consist of administrative water losses. In Türkiye, however, physical water losses are generally higher than administrative water losses (Muhammetoğlu H. & Muhammetoğlu, A., 2017).

The water supply infrastructure in Türkiye comprises reservoirs, dams, pipelines, and treatment facilities. Water for agricultural, industrial, and domestic use mostly received from stored water via dam construction. However, the distribution network often faces challenges such as aging pipes, leaks, and inefficient water use. Steps to prevent water loss and leakage in Türkiye have been brought to the agenda within the scope of compliance with the EU WFD. The measures program, created at the level of the MoAF, has also been reflected in the 10th Development Plan and the relevant action plans of Development Agencies across Türkiye. According to these action plans, "Water losses and leaks will be prevented, and the use of healthy and environmentally friendly materials will be promoted by improving the existing networks." The most significant step taken to implement measures against water loss and leakage nationwide was the "Regulation on the Control of Water Losses in Drinking Water Supply and Distribution Systems," which came into force last year. With this regulation, municipalities will be required to gradually reduce the loss-leakage rate to 25% over a ten-year period. Projects for "Water Distribution and Control Systems," initiated in provinces such as Istanbul, Denizli, Sakarya, and Kayseri, are becoming more widespread across Türkiye each day (GSL, 2024).

The effective use of drinking and utility water and the avoidance of waste depend on minimizing water leaks and losses along the pipeline from the facilities where water is supplied to the points where it reaches the user. While the acceptable maximum value for this rate is 10%, the rate of water leaks and losses in Türkiye is around 33% according to the MoAF's statement (MoAF, 2023b). Preventing water loss and leaks will not only save valuable natural resources but also make it possible for more users to access clean drinking and utility water.

Cities are increasingly affected by climate change in diverse ways. One of the fundamental challenges today is the accurate identification of risks and hazards stemming from climate change that cities face. Therefore, a priority step in adapting to climate change impacts and reducing disaster risks in cities involves conducting assessments of impacts, vulnerability, and risks. Considering these analyses, it is crucial to prepare and implement Local Climate Action Plans that prioritize actions for climate adaptation and greenhouse gas reduction (Tuğaç, 2022). Many examples illustrate that traditional grey infrastructure solutions are inadequate or entail high costs under changing climate conditions. Nature-based solutions typically incur at least 50% lower costs compared to grey infrastructure. Through green infrastructure, it becomes possible to mitigate disaster risks and adapt to the impacts of climate change in cities, while also serving as significant carbon sinks (Tuğaç, 2022).

Another critical issue that requires careful attention in cities is water management, as climate change affects the water cycle. This manifests as extreme rainfall in some regions and drought in others. Impermeable urban surfaces exacerbate urban flooding and exacerbate floods and flash floods in areas with heavy rainfall. This situation particularly highlights the importance of managing rainwater in cities and within the scope of green infrastructure applications; flood parks, vegetated rainwater trenches, permeable surfaces, green sidewalks, green roofs, restored natural water channels, rain gardens, and urban forests are considered as solutions in this context. Implementing these solutions will enhance cities' resilience against climate change impacts (Tuğaç, 2022).

Urban populations are expanding, placing increasing pressure on infrastructure and natural resources. The concept of "Smart Water Cities" emerges as a strategic approach to tackle these challenges through innovative technologies and integrated management systems. By leveraging real-time data analytics and monitoring through sensors and IoT devices, authorities can monitor usage patterns, detect leaks promptly, and accurately forecast demand fluctuations. Integrated infrastructure is central to the concept of Smart Water Cities. (Hattum et al. 2016; Bouramdane, 2023)

Climate change mitigation in urban areas through green energy transformation is crucial not only from an environmental perspective but also economically and socially beneficial. Implementing zero waste practices in cities is essential. The concept of a circular economy, focusing on recycling and waste management, emphasizes the principles of "reduce, reuse, and recycle." It is crucial for Türkiye to leverage solutions for greenhouse gas reduction and adaptation in its cities, given its location in the highly climate-sensitive Mediterranean Basin. In Türkiye, various institutions, including local governments, are involved in significant projects and activities addressing climate change. Following Türkiye's commitment to the Paris Agreement, it has set a net-zero carbon targets for 2053 and adopted a green development policy. The implications of this policy across all sectors are inevitable and profound. Implementing effective climate change mitigation and adaptation actions in cities where these sectors predominantly operate will not only enhance climate resilience but also support green development, creating new opportunities for jobs and employment. Initiating the planning of future green cities today is crucial, as it represents a significant responsibility not only to the current generation but also to future generations. (Tuğaç, 2022)

In the context of climate adaptation, governing urban water resources differently becomes imperative to ensure socio-environmental justice in urban climate interventions (Radonic & Zúñiga-Terán, 2023). Municipalities and water resource managers are increasingly focusing on policies and programs that align with climate adaptation goals, emphasizing the importance of integrating equity, ecology, and geography considerations into urban water management practices. Furthermore, the nexus between climate governance and urban water management underscores the interconnectedness of climate change mitigation and water resource sustainability in urban settings (Tosun & Leopold, 2019). Also, increased awareness of climate change can enhance the management and protection of water resources by influencing public perceptions of water supply and demand (Wang, 2024). Furthermore, the compounding impacts of human-induced water stress and climate change underscore the urgency of addressing water availability challenges in the context of a changing climate (Mehran et al., 2017).

Resilience in urban water services becomes paramount in the face of disasters, climate change impacts, and increasing water demand, necessitating sustainable approaches to ensure the provision of safe drinking water, sanitation, and drainage in cities (Johannessen & Wamsler, 2017). Decision-making processes for adaptive water management in urban watersheds require a comprehensive understanding of environmental hotspots, water quality issues, and suitable management options to address the impacts of climate change and urbanization (Kim & Ryu, 2020). The role of spatial planning in sustainable urban water management is crucial for enhancing resilience and efficiency in urban water supply systems amid climate change challenges (Hurlimann & Wilson, 2018).

Addressing the impacts of climate change on water supply and sanitation infrastructure requires a multi-faceted approach that considers not only the physical resilience of systems but also the social, economic, and environmental factors that influence access to clean water and sanitation services. By integrating climate resilience into water and sanitation planning and management, stakeholders can work towards ensuring sustainable and equitable access to WASH services in the face of a changing climate. By prioritizing climate adaptation strategies, sustainable water management practices, and resilience-building measures, urban areas can enhance their capacity to cope with the impacts of climate change on water resources and ensure the long-term viability of urban water systems

3.3. Other water users

The effects of climate change on water resources directly influence industrial operations, with changes in precipitation patterns and water availability affecting water quality and quantity for various users. These water availability and quality changes pose risks to industrial water management, impacting the sustainability and economic viability of water service provision and treatment processes (Roeger & Tavares, 2021).

Water resource system modeling plays a crucial role in industrial adaptation to climate change, providing insights into future water availability, economic value, and environmental flows. Governments and industries rely on such models to adapt to changing climatic conditions and ensure sustainable water management practices. By incorporating climate adaptation strategies into water resource systems, industries can enhance their resilience and preparedness for the challenges posed by climate change (Borgomeo, 2022). Proactive measures to address the impacts of climate change on conjunctive water use are critical for ensuring the reliability and sustainability of water resources in industrial operations (Zhang, 2015).

Groundwater management is a key consideration for industrial water use, with depletion in many regions necessitating sustainable management practices to meet the demands of agriculture, industry, municipal supply, and ecosystems. Subsurface storage management offers a viable option to address water scarcity and ensure the sustainable use of groundwater resources. By integrating groundwater management into industrial water practices, industries can enhance water security and resilience in the face of climate change impacts (Green, 2016).

Climate change-induced droughts can disrupt water availability and quality, affecting industrial activities reliant on water resources. Adapting to variable water supply conditions is essential for industries to maintain operational continuity and sustainability in the face of changing climate patterns (Chang & Bonnette, 2016).

The energy sub-sector, which falls between services and industrial sectors, alone, consumes approximately 75% of the total water used by these sectors. A significant amount of water is used in energy production for various purposes, including pumping oil, cleaning pollutants at power plants, producing steam necessary for turbine operation, and cooling power plants. Understanding the dynamics of water and energy is crucial for tackling challenges like climate change and sustainable resource management (Coskun Dilcan, 2023).

Effective water management for industrial development is vital for energy conservation and subjective attitudes. A comprehensive risk-oriented model is needed to address the tolerance of imbalanced water allocation issues, highlighting the significance of efficient industrial water resource management (Yu et al., 2021). Furthermore, adaptation measures for the food and beverage industry in response to climate change's impact on water availability are essential to ensure sustainable operations and resource use (Valta et al., 2015).

The impact of climate change on groundwater recharge rates in regions such as the Küçük Menderes River Basin in Western Türkiye underscores the vulnerability of water resources to changing climatic conditions (Yağbasan, 2016). As temperatures increase and precipitation patterns shift, the recharge rates of groundwater sources are influenced, creating challenges for industries that rely on groundwater for various processes.

Climate change poses significant risks to Türkiye's vital tourism sector, the ongoing water issues in the Bodrum Peninsula are expected to worsen due to climate change. According to a study Koç et al., (2017) competition for water among residential, agricultural, and industrial sectors intensifies during the summer months, driven by tourism demands. The daily water demand during the summer population is nearly twice that of the winter population, and projections indicate that daily water needs will increase sixfold between 2000 and 2060. To address these challenges, The DSI initiated an Emergency Drinking Water Project in 2011, aiming to ensure a sustainable drinking water supply to the Peninsula by 2040.

Projections for Türkiye suggest a rise in temperatures and a decrease in precipitation, which could have implications on water-intensive sectors like agriculture and industry (Gürkan et al., 2020). The anticipated changes in climate patterns underscore the importance of implementing effective water management policies to address water-related challenges exacerbated by climate change, particularly in regions like the Konya province of Türkiye. The Konya Plain in Türkiye is experiencing land subsidence and groundwater depletion issues, worsened by climate change and inadequate water management policies (Calò et al., 2017).

In the Upper Euphrates Basin in Türkiye, the analysis of long-term streamflow trends concerning temperature and precipitation highlights the intricate interactions between climate change and water resources management (Yildiz et al., 2019).

In 2022, a total of 19.2 x $10^9 m^3$ year of water was abstracted from various water resources via various entities including municipalities, villages, manufacturing industry establishments, thermal power plants, organized industrial zones, and mining establishments. This marks an increase from the total water abstraction of 18.2 x $10^9 m^3$ year recorded in 2020 In addition to this, the distribution of fresh water abstraction from water resources among various entities like municipalities accounted for 80.3%, manufacturing industry establishments for 8.6%, villages for 4.7%, mining establishments and organized industrial zones for 4.9% and thermal power plants for 1.5% of the total amount abstracted in 2022 (TUIK, 2023).

On average, 20% of the water withdrawn globally is used for industry. In Türkiye, this rate was 17.2% in 2012 and is expected to reach 20% by 2030, which is similar to the world average. In Europe, an average of 40% of the water supplied is used in industry. These rates also include water used for energy production (cooling water in thermal power plants). Excluding the amounts of water used for energy production in industry, the rate of water used for industrial production (manufacturing industry, organized industrial zones, mining operations) in our country drops to 4%. The European average is reported to be 10%. (Çapar & Yetiş, 2018).

In Türkiye, the water footprint of production is approximately 139.6 x x $10^9 m^3$ year. Of this water footprint, 4% is attributed to industry. The water footprint of consumption is approximately 140.2 x x $10^9 m^3$ year, with 6% of this footprint coming from industry (ICoI, 2024). According to the 2022 water statistics for Türkiye's manufacturing industry sub-sectors, the manufacture of basic metals and fabricated metal products recorded the highest volume of abstracted water. This was followed by the manufacture of chemicals and the manufacture of textiles and leather products (Table 11).

Table 11. Water statistics of manufacturing industry sub-sectors in Türkiye

Sub-sectors	Abstracted water 10^3 m^3		Abstracted water, excluding for cooling purpose, 10^3 m^3	
	2020	2022	2020	2022
Manufacturing industry, including	**2,842,208**	**3,065,013**	**734,670**	**854,931**
Food, beverage, and tobacco products	163,245	220,130	143,199	196,989
Textiles, wearing apparel and leather products	219,480	240,052	214,856	234,329
Wood, wood products, and cork (except furniture)	10,197	18,626	7, 881	9,237
Pulp, paper, paper products and recorded media	35,712	40,121	35,480	38,977
Manufacture of coke, refined petroleum products	32,200	32,133	21,905	22,336
Chemicals, chemical products, basic pharmaceutical products, rubber, plastic products	493,407	485,641	125,489	135,304
Other non-metallic mineral products	61,956	78,830	45,609	60,517
Basic metals and fabricated metal products	1,790,262	1,909,274	106,316	118,858
Computer, electronic and optical products, electrical and machinery equipment, motor vehicles, trailers and semitrailers and others	30,242	33,940	28,481	32,203
Furniture, other manufacturing, repair and installation of machinery and equipment	5,507	6,266	5,454	6,181
Source: TurkStat, Water and Wastewater Statistics, 2022				
Note: Manufacturing industry establishments' local units having 50 or more employees are covered.				
Figures in table may not add up to the totals due to rounding.				

Municipalities, villages, manufacturing industry establishments, thermal power plants, organized industrial zones and mining establishments discharged 16.4 x $10^9 m^3$ of wastewater to receiving bodies. Out of this amount, 76.5% was discharged to sea, 19.5% to rivers, 1% to dams, 0.8% to septic tanks, 0.7% to lakes and artificial lakes, 0.2% onto land and 1.4% to other receiving bodies. The 80.2% of wastewater, discharged to sea was cooling water, 79.3% of wastewater (excluding cooling water) discharged directly to receiving bodies was treated. Out of the total amount of wastewater discharged by municipalities, villages, manufacturing industry establishments, thermal power plants, organized industrial zones and mining establishments, 61.6% was cooling water, whereas 38.4% was other wastewater (TUIK, 2023).

In addition to water treatment and recycling, water efficiency-focused approaches are needed to achieve water savings in the processes where water is used. There are various applications such as high-pressure and low-volume hose nozzles, automatic shut-off systems, low-water-consumption sprays, spray balls for tank cleaning, and steam and ultrasonic cleaning instead of hot water washing (NuWater, 2024).

The Ministry of Agriculture and Forestry has prepared the "Water Efficiency Strategy Document and Action Plan (2023 - 2033) in the Framework of Adapting to the Changing Climate". Türkiye's water strategy is based on the rational, collaborative, effective, efficient, and equitable use of water across all sectors within the framework of sustainable development goals. In this context, rainwater harvesting, greywater reuse, and the reuse of treated wastewater are gaining importance among alternative sources. It is now possible and encouraged to use alternative water sources such as indoor and outdoor rainwater harvesting and the reuse of treated greywater within buildings, including industrial facilities (MoAF, 2023a).

Within the scope of the Water Efficiency Mobilization in Türkiye, it is aimed to achieve up to 50% water savings in the industrial sector by increasing water use efficiency in industrial activities and spreading efficiency measures (ICoI, 2024).

As of 2021, the rate of treated wastewater reuse in Türkiye is 2.5%. However, with the implementation of recent projects, this rate has increased. The 4% target set for 2022 was achieved by July 2022. According to the projections of the Ministry of Environment, Urbanization, and Climate Change, the goal is to increase the rate of treated wastewater reuse to 5% by 2023 and to 15% by 2030 (ICoI, 2024).

The Climate Change Adaptation Project in Water Resources, conducted by the Ministry of Agriculture and Forestry General Directorate of Water Management, includes the most up-to-date research results on greywater and rainwater harvesting across various building typologies. Two of the most important outputs of this project are the Rainwater Harvesting and Greywater Use Guideline Documents. For other water-dependent sectors (drinking water, industry, tourism, etc.), the goals include reducing pollution of receiving environments where discharges occur, controlling pollution at the source as much as possible, separately collecting rainwater and waters with different pollution loads, and ensuring dual plumbing systems in all types of buildings (existing and planned residential areas, sports complexes, hotels, tourism centers, public buildings, hospitals, schools, stadiums, shopping centers, office buildings, airports, industrial facilities, etc.). Additionally, the separate collection of domestic wastewater streams and considering technical and economic feasibility should be targeted (MoAF, 2023c).

In Türkiye, the food sector, which consumes 22% of the industrial water, is the largest water consumer, followed by the textile sector with 18% usage. Another significant water-using sector is the chemical industry, which accounts for 16% of the water used in industry. Together, these three sectors account for more than 50% of the total industrial water use. The metal industry, which uses 7% of the total industrial water, is another notable sector with high water consumption. Water usage in all other sectors outside of food, textile, chemical, and metal industries represents 37% of the total industrial water use in Türkiye (ICoI, 2024).

Climate change risks for the industrial sector are split into physical and transition risks. Physical risks include climate impacts like droughts, heatwaves, and floods, which are expected to worsen over time (IPCC). Transition risks arise from moving to a low-carbon economy, affecting carbon-intensive sectors through asset depreciation and higher production costs. Chemical production is especially impacted by water stress. Hazards affecting manufacturing differ from those impacting energy sectors, with varying degrees of impact. Differences in assets, space usage, water needs, and other factors influence sectoral sensitivities. In manufacturing, water usage and extreme temperatures are the greatest concerns, making it highly vulnerable to water stress (ICoI, 2024).

Industrialists must adopt mitigation and adaptation activities to address climate change. In Türkiye, 12 sectors are highly likely to be affected. To improve water use efficiency in the industrial sector, the MoAF and GDWM conducted the Industrial Water Use Efficiency Project. This project analyzed sectoral water consumption data from the Industrial Registry Information System using NACE codes, identifying 400 pilot facilities in 35 major sectors with high water consumption, including textiles, food, chemicals, and primary metals. Site visits and interviews determined sectoral water use, wastewater generation, needed measures, and potential water savings. As a result, the Water Efficiency Strategy Document and Action Plan for 2023 – 2033 was developed, outlining goals and strategies for all water-using sectors for the next 10 years and providing solutions to challenges (MoAF, 2023a).

Additionally, planning recommendations for reducing climate change impacts on industrial water use are included in the Adaptation Policies section of the Climate Change and Water Resources Project. The report evaluates adaptation activities across various sectors, compiling examples from different regions. Selecting sectors that represent Türkiye and are vulnerable to climate change is essential. Therefore, based on other countries' scopes, 12 main sectors were selected for Türkiye (MoAF, 2016*)*. The sectoral divisions for ranking adaptation activities include Health, Agriculture, Food Security, Forestry, and Biodiversity, Water Resources, Infrastructure (Buildings, Transportation, and Energy), Urban and Basin Planning, Buildings, and Settlements, Coastal Areas, Marine Environment and Fisheries, Tourism, Industry–Commerce and Energy, Research and Development, Information, Education, and Training, and Financing and Insurance (ICoI, 2024).

According to the "Climate Change and Water Management: Industrial Sector Report" published by the ICOI in 2024, it is emphasized that industries with specific water consumptions close to the lower limits of Clean Production (CP) standards could achieve additional water savings of 20 – 90% through greywater recovery, rainwater harvesting, or sector-specific CP practices (ICoI, 2024).

The report also indicates that the following points should be considered for water and wastewater management in the industry (ICoI, 2024):

- Establishing a "Water Balance (Budget)": This involves thoroughly determining the facility's water needs and wastewater characteristics.
- Utilizing the "Industrial Water Use Efficiency Project by NACE Codes": Identify water efficiency options using sectoral best available techniques (BAT) and compare them with existing water consumption values.

- Water efficiency options should be classified into various measures, including in-plant control, improvement of production technologies, advanced treatment and reuse
- Best Available Techniques (BAT) for production and auxiliary processes should be applied in a way that does not negatively affect product quality.
- Reuse of treated wastewater for domestic purposes should be supported by social approval from employees.
- Economic feasibility of options should be assessed, and the results should be used in developing water efficiency plans.
- Implemented water efficiency plans should be used to improve the facility's water management.

Encouraging effective water management and leveraging green finance opportunities are crucial for reducing the corporate carbon footprint and supporting circular economy goals (ICoI, 2024).

To reduce the water footprint, companies must understand and address water-related issues from social, economic, and environmental perspectives. This involves measuring water use and risks across supply chains, mitigating impacts in water-scarce areas, supporting water access agreements, and collaborating with various stakeholders for water sustainability. Integrated water management strategies are crucial for addressing the impacts of climate change on industrial water use in Türkiye, especially in water-demanding regions like Istanbul with diverse water resources (Cüceloğlu et al., 2017). Through tools like the Soil and Water Assessment Tool (SWAT), assessments of climate and land-use impacts on water resources can guide sustainable water management practices in Türkiye.

Policy interventions and adaptation strategies in Türkiye recognize the limited research on the socio-economic impacts and costs of adapting to climate change, emphasizing the necessity for interventions in water resources management to tackle climate-induced challenges (Turhan et al., 2016). With potential impacts on water availability, agriculture, natural disasters, and freshwater ecosystems, climate change requires proactive measures to ensure the resilience of industrial water management practices in Türkiye.

The evaluation of water security effectiveness in integrated river basin management is vital for addressing climate change impacts on water resources in Türkiye (Ak & Benson, 2022).

In conclusion, the effects of climate change on industrial water use and management underscore the need for proactive adaptation strategies, sustainable practices, and resilience-building measures. Collaborative efforts between industries, governments, and stakeholders are essential to navigate the complexities of climate change impacts on industrial water management and foster a more resilient and sustainable water future. In this context, the effects of climate change on industrial water use and management in Türkiye necessitate a comprehensive approach integrating scientific research, policy interventions, and stakeholder engagement. By implementing adaptive strategies, sustainable water management practices, and resilience-building measures, Türkiye can enhance its capacity to address the challenges posed by climate change on industrial water use and ensure the long-term sustainability of water resources in the country. Collaborative efforts among industries, government agencies, and research institutions are essential to navigate the complexities of climate change impacts on industrial water management and promote a more resilient water future in Türkiye.

3.4. Trends on depletion of the water resources and water demand forecasting

In Türkiye, climate change impacts directly threaten the availability of water resources (MoEU, 2012). The air temperatures in the Mediterranean region are exceeding seasonal averages, resulting in decreased water resources, increased drought conditions, as well as changes in marine ecosystems. In Konya, Central Anatolia, shifts in seasons and diminishing water resources have resulted in lower agricultural productivity and rising food prices. The adverse effects on agriculture have led to internal migration, compounded by the loss of wetlands essential for alleviating the impacts of climate change, as well as increased occurrences of drought and erosion (TEMA-WWF Türkiye, 2015). In Southeast Anatolia, diminishing water resources and observed winter droughts have heightened the need for water extraction from deep wells, thereby raising energy demands. In Eastern Anatolia, climate change has negatively impacted winter tourism, agriculture, plant patterns, and livestock grazing. In the Black Sea region, a rise in both the frequency and intensity of extreme weather events has contributed to a decline in the local population, decreased productivity in tea and hazelnut farming, and an uptick in disasters like landslides. Furthermore, locals have reported that rising sea temperatures have facilitated the arrival of invasive species in the Black Sea, adversely affecting the fishing industry. In the Aegean and Marmara regions, the increasing pressure on water resources has complicated the supply of water to cities, negatively impacting agriculture, livestock, and fishing sectors. Impact assessment surveys revealed that 70% of respondents observed the effects of climate change in the energy sector, 74% in agriculture, and 60% in tourism (TEMA-WWF Türkiye, 2015).

The "Impact of Climate Change on Water Resources – ClimaHydro" project is a comprehensive study conducted to assess the effects of climate change on surface and groundwater resources and to identify adaptation activities on a river basin basis in Türkiye (MoAF, 2016). This project covers the period from 2015 to 2100. In the initial phase, climate projections were made using the outputs of three global models from the IPCC's 5th Assessment Report, as well as the outputs of the RegCM 4.3 regional climate model, encompassing the entire country. The RCP 4.5 and RCP 8.5 emission scenarios, developed by the IPCC and widely preferred globally, were used for these projections.

As part of the project, model simulations were used to create projections for 8 parameters and 17 climate indices that represent extreme conditions, all at the basin scale. Differences in these parameters were calculated as seasonal and annual averages for 10-year and 30-year periods, comparing them to the reference period of 1971 – 2000, extending to the year 2100. This initiative is significant as it represents the first-time results for Türkiye have been obtained from three global climate models at a resolution of 10 x10 km. The data calculations were based on the assumption that atmospheric equivalent CO_2 concentrations would reach approximately 1370 ppm under the RCP 8.5 scenario and about 650 ppm under the RCP 4.5 scenario.

The project involved a sectoral impact analysis, where a methodology was created to evaluate the effects of climate change in Türkiye on essential sectors, including drinking and utility water, agriculture, industry, ecosystems, tourism, and energy. By taking into account climate change projections for three designated pilot basins, the analysis assessed how water affects these sectors. The impact severity for each sector was classified into categories of "low impact, medium impact, high impact, and very high impact" (MoAF, 2016).

The project simulations reveal significant warming trends in Türkiye from 2015 to 2100, evident on both seasonal and annual scales. Although the early years of this period may show minor temperature fluctuations and even some cooling in specific regions, the rise in greenhouse gas emissions is expected to accelerate temperature increases in subsequent years. Projections indicate that winter temperatures will be at least 1°C higher after 2050 compared to the 1970 – 2000 baseline. Additionally, it has been noted that temperature increases will be more pronounced in summer and spring than in winter and autumn. Over the 2015 – 2100 timeframe, temperature rises are observed to diminish from south to north across the country. The most significant increases are expected in the southeastern region and along the Mediterranean coast. By the 2100s, temperature rises in eastern and southeastern Türkiye are projected to reach between 4 – 6 ^{o}C (MoAF, 2016).

Rising daytime temperatures are projected to result in more frequent and severe heat waves in these areas. Moreover, higher nighttime temperatures will hinder the ability of both people and animals to cool down, intensifying the adverse effects of heat waves. This situation will also lead to increased energy demand for cooling, both during the day and at night. Alongside expected rainfall shortages, the rise in evaporation rates will amplify stress on water resources and the agricultural sector. Additionally, it has been noted that the tourism industry along the Mediterranean coast will require restructuring (MoAF, 2016).

The model simulations of the project suggest that the climate in the northern basins of Türkiye will be wetter in the compared reference period. Specifically, the RCP 8.5 scenario forecasts that from the 2050s onward, drought conditions in these basins will worsen as one moves southward, with decadal average annual rainfall totals dropping to around 150 mm. Notably, the lowest rainfall values projected for Türkiye between 2015 and 2100 are anticipated in the Konya Closed Basin. When analyzing rainfall changes by basin as a percentage of total annual precipitation, the most significant declines are found in the Eastern Mediterranean, Western Mediterranean, and Ceyhan basins. Under the RCP 4.5 scenario, reductions in annual rainfall totals in these areas are estimated to be between 12% and 15% in the last decade of the century, whereas the RCP 8.5 scenario predicts reductions of 20% to 25%. In the Euphrates-Tigris Basin, annual rainfall is expected to decrease by 3% to 8% under both scenarios (MoAF, 2016).

The effects of the RCP 4.5 and RCP 8.5 scenarios on all three models vary across the basins located in western Türkiye, including the Meriç-Ergene, Marmara North Aegean, Susurluk, Gediz, Küçük Menderes, and Büyük Menderes basins. Under the RCP

4.5 scenario, the HadGEM2-ES and CNRM-CM5.1 model simulations predict that the climate regimes in the Marmara, North Aegean, Meriç-Ergene, and Küçük Menderes basins will be wetter compared to the reference period. In contrast, the MPI-ESM-MR model forecasts increased rainfall in the Eastern Black Sea, Western Black Sea, Marmara, and Yeşilırmak basins (MoAF, 2016).

The project, which encompasses hydrological projections, demonstrates that, for the first time in Türkiye, the water potential of all basins has been assessed using a unified hydrological model. As part of the hydrogeological projections, changes in hydrogeological reserves have been analyzed for each basin, with the Meriç-Ergene and Euphrates-Tigris basins recognized as the least affected in Türkiye. In contrast, the most significant impacts of climate models and scenarios have been observed in the Asi Basin. Furthermore, the basins that have been most affected include Burdur, North Aegean, Western Mediterranean, and Akarçay, particularly in western and central Türkiye, ranked from highest to lowest impact (MoAF, 2016).

Hydrological projections forecast a decrease in total flow in Türkiye relative to the reference period. According to the HadGEM2-ES climate model outputs, median gross water potentials are expected to decline by 40 – 45% across three sub-periods from 2015 to 2100 compared to the reference period median. In contrast, the MPI-MSM-MR climate model predicts a reduction of 15 – 20% Throughout all timeframes, the most significant water deficits are anticipated in the Euphrates-Tigris, Eastern Mediterranean, and Konya Closed Basins. Notably, in the Konya Closed Basin, the HadGEM2-ES model projects precipitation decreases of 10 to 30 mm under the RCP 4.5 scenario for the 2015 – 2100 period. According to outputs from the HadGEM2-ES climate model, median gross water potentials are expected to decrease by 40 – 45% across three sub-periods from 2015 to 2100, relative to the median of the reference period. In contrast, the MPI-MSM-MR climate model forecasts a reduction in water potential of 15 – 20% Throughout all timeframes, the most significant water deficits are anticipated in the Euphrates-Tigris, Eastern Mediterranean, and Konya Closed Basins. Specifically, within the Konya Closed Basin, the HadGEM2-ES model projects precipitation reductions ranging from 10 to 30 mm under the RCP 4.5 scenario for the 2015 – 2100 period (Figure 9).

Under the RCP4.5 scenario, the HadGEM2-ES model identifies the Eastern Black Sea and Çoruh Basins as having a consistent water surplus throughout all periods. Similarly, in the Marmara, Susurluk, North Aegean, Western Black Sea, Yeşilırmak, Antalya, Aras, and Lake Van Basins, the estimated net water levels are deemed adequate for projected usage across all forecast periods. Conversely, notable water deficits are expected in the Euphrates-Tigris Basin, as well as in the Eastern Mediterranean and Konya Closed Basins, especially during the 2041 – 2100 timeframe. Other basins may face minor water deficits throughout the projection periods. The 2041 – 2070 period is highlighted as the most critical 30-year window for water availability nationwide.

In addition to the findings of the “ClimaHydro” project, a recent study (Pilevneli et al., 2023) has investigated the impact of climate change on agricultural production in 25 river basins of Türkiye, with a focus on water availability assessment using a volumetric water footprint approach. In this study, two-greenhouse gas concentration pathways, RCP 4.5 and RCP 8.5 were used for three periods from 2015 to 2100. It was shown that the highest impact of climate change on water availability is expected to be observed during the 2015 – 2040 period (Figure 10). The irrigation water demands showed the risk of water deficiency with a possible decrease from a surplus of 14.6 x $10^9 m^3$year to a deficit of 57.3 x $10^9 m^3$year under the RCP 8.5 scenario for the 2071 – 2100 period. The estimated cost of climate change was found to be between 14.15 billion EUR/ year and 18.01 billion EUR/ year if no action is taken. Therefore, this study emphasizes that there is an urgent need to increase water use efficiency and productivity in 15 river basins. The ranking of agricultural products according to their annual production, income and blue water footprints revealed that among the 12 priority key products, maize and wheat are highly vulnerable to drought as a consequence of climate change.

In Türkiye, potential adaptation measures that the drinking water, agriculture, and industrial sectors can take against climate change include; reducing loss and leakage rates in drinking water supply, implementing rainwater harvesting, using water-saving fixtures in showers and toilets, and reusing domestic wastewater. In the agriculture sector, it is important to select crop patterns suitable for climate change, completely abandon flood irrigation, promote efficient irrigation techniques like drip irrigation, apply deficit irrigation where appropriate, and adopt organic farming and good agricultural practices, while also improving irrigation efficiency and raising farmer awareness. For industrial facilities, promoting clean production practices, enhancing internal controls, establishing a zero discharge approach, and recovering wastewater for reuse in processes and similar applications are essential (Capar, 2019).

HadGEM2-ES model RCP 4.5 scenario ***HadGEM2-ES model RCP 8. 5 scenario***

2015-2040 period

2041-2070 period

2071-2100 period

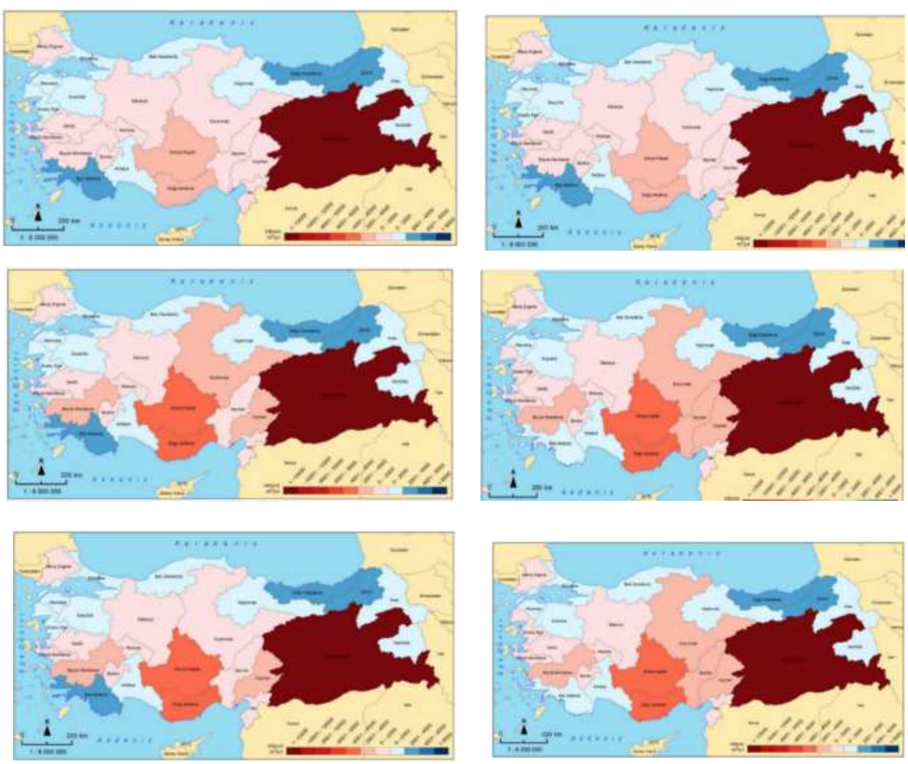


Figure 9. River basin water surplus/deficit maps for three different climate projection periods

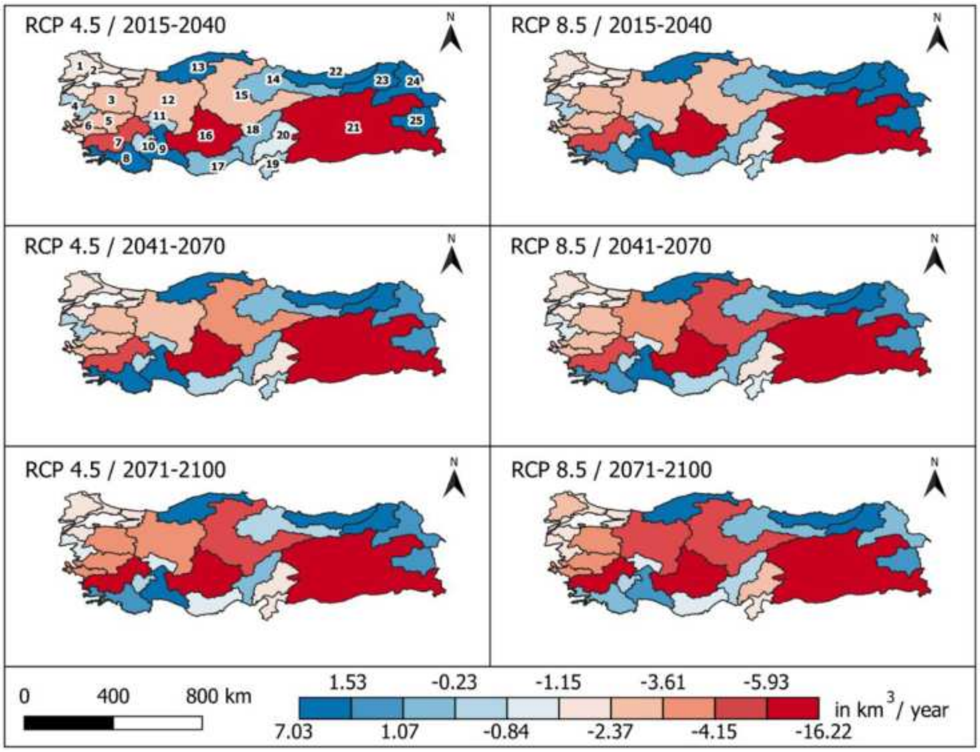


Figure 10. Water budget in the river basins for the projected periods

Management plans for 25 basins in Türkiye should be developed with a focus on climate change, accompanied by ongoing monitoring and improvement activities. In addition to organizing efforts within these basins, it is vital to implement management plans at provincial and regional levels. Collaboration among sector leaders and stakeholders will enhance participation in the decision-making processes related to water management, ensuring comprehensive and effective governance. In Southeastern Anatolia, where temperature increases and potential heat wave impacts are pronounced, it is crucial to establish drought mitigation strategies for the 2015 – 2100 period. This can be achieved by accelerating afforestation, conserving water resources, and raising public awareness about the anticipated effects of climate change. To mitigate potential negative outcomes, a scientific examination of the impacts on agricultural products, livestock, and public health should be conducted, followed by the implementation of appropriate measures (Capar, 2019).

The Euphrates and Tigris rivers, as transboundary water resources, require information sharing with neighboring countries to prevent potential dispute and foster cooperative solutions. Residents in Southeastern and Eastern Anatolia need to be informed about changes in rainfall timing and river flow patterns. Given expected shifts in vegetation, research into high-value agricultural products is necessary, alongside measures to protect pasture livestock farming. Additionally, regions such as the Eastern and Western

Black Sea, along with the Çoruh Basin, face increased rainfall and risks of flooding and landslides, necessitating protective measures and public education on these issues. Finally, to address anticipated water scarcity, strengthening public administration, promoting efficient water use practices, and fostering coordination among universities, public institutions, and civil society are essential for resilient water management in Türkiye (Capar, 2019).

CHAPTER 4. WATER TARIFFS AND INVESTMENTS

4.1. Public investments

Public investments encompass a wide range of activities, including agricultural water management, irrigation, water use efficiency measures, water infrastructure improvements, and water purification. This is essential in water infrastructure for addressing water scarcity, improving water quality, and ensuring sustainable access to safe drinking water and sanitation (Hagihara et al., 2004; Macchiaroli et al., 2023). By strategically allocating resources to infrastructure projects, governments can enhance the quality of life for their citizens and support economic growth through improved water services. This is important funding allocations for various sectors, including water infrastructure and environmental protection to meet the urgent requirements for economic growth, job opportunities and resilience and sustainability of essential services like water supply and sanitation (Zhang & Batjargal, 2022). It allows for improved health by reducing the incidence of waterborne diseases through water purification and wastewater treatment (Hagihara et al., 2004). Additionally, investments in water infrastructure can have positive spillover effects on education, health, and household welfare.

Investments in rural water infrastructure can have far-reaching impacts beyond access to clean water, enhance women's participation in economic activities, promote girls' education by reducing water-related burdens, and ultimately contribute to gender equality and socio-economic development (Rost & Koissy-Kpein, 2018).

Public investments in water infrastructure in Türkiye play a crucial role in ensuring water security, sustainable development, and climate change resilience. Türkiye has been focusing on maximizing its hydropower potential through the development of small-scale hydropower projects (Kibaroğlu, 2022). These initiatives are essential for meeting the country's energy needs while also contributing to water resource management. Moreover, sustainable water policies and planning initiatives are being implemented in Türkiye to address the impact of climate change on water resources and to propose long-term water management strategies (Babaoğlu, 2023).

In Türkiye, while urban areas benefit from extensive sewer networks and wastewater treatment facilities, rural regions still struggle with achieving adequate sanitation coverage. To tackle these issues, the government has introduced various initiatives and policies focused on infrastructure investment, regulation and standards, and public awareness.

The distribution network faces challenges such as aging pipes, leaks, and inefficient water use, however Türkiye needs to align with and implement the EU Water Framework Directive. The Ministry of Agriculture and Forestry has incorporated these efforts into the 10th Development Plan and the action plans of involved Development Agencies across Türkiye. According to these plans, "Water losses and leaks will be minimized, and the use of healthy and environmentally friendly materials will be promoted by upgrading existing networks". A significant step towards mitigating water loss and leakage nationwide was the "Regulation on the Control of Water Losses in Drinking Water Supply and Distribution Systems" which was enacted in 2023. This regulation mandates that municipalities reduce the loss-leakage rate to 25% within a decade. Projects such as "Water Distribution and Control Systems," initiated in cities like Istanbul, Denizli, Sakarya, and Kayseri, are expanding across Türkiye (GSL, 2024).

A total of 1,390 out of 1,391 municipalities were served with drinking and utility water network. The ratio of the population served with drinking and utility water network to the total municipal population was determined to be 98.8%. Of the total 6.7 x10^9 m^3 of water extracted from sources, 4.1 billion m^3 was treated in drinking and utility water treatment plants. Conventional treatment was applied to 90.4% of the treated water, advanced treatment to 9.6%, and physical treatment to 0.03% (TUIK, 2023).

A total of 1,366 out of 1,391 municipalities were served with a sewer network. The ratio of the population served with a sewer network to the total municipal population was determined to be 92.8%. Of the 5.4 billion m^3 of wastewater discharged from the sewer network, 4.6 billion m^3 was treated in wastewater treatment plants. Of the treated wastewater, 52.7% received advanced treatment, 25.2% received biological treatment, 21.7% received physical treatment, and 0.4% received natural treatment. 1.5% of the treated wastewater was reused in industrial, agricultural irrigation, and other areas. The ratio of the population served with a wastewater treatment plant to the total municipal population was determined to be 77.7% (TUIK, 2023).

While the acceptable maximum rate for these losses is 10%, Türkiye's current rate is around 33% (MoAF, 2023b).

Public investments in agricultural water management and irrigation are vital for enhancing agricultural productivity and ensuring food security in the context of agriculture. These investments involve expenditures in irrigation and drainage development, institutional reform, capacity building, and governance improvements (Nhemachena et al., 2018). Public investments in water infrastructure are essential for supporting agricultural activities and promoting sustainable water use in the country (Rezaei et al., 2023).

According to the 2023 Investment Program of the Presidency of the Republic of Türkiye's Strategy and Budget Directorate, out of the total investment allocation of 454.2 billion TL, 9.8% has been allocated to the energy sector, and 9.6% to the agriculture sector. The total share of other sectors, including drinking water and sewage, technological research, and environment, has been projected as 14.3%. The General Directorate of State Hydraulic Works (DSI) is among the institutions allocated the highest investment budget under the Central Government Budget, receiving 37.7 billion TL, of this, 22.1

billion TL has been allocated for agricultural irrigation investments, with plans to irrigate approximately 191,000 ha. of land. Additionally, 6.5 billion TL has been allocated for flood protection projects. To meet the increasing drinking water needs of municipalities due to climate change and population growth, 4.3 billion TL has been set aside (SBD, 2024).

During 2003- 2018, a total of 125.8 billion TL was invested in water resources in Türkiye. Since 2003, 7,200 facilities have been put into service, including 508 dams, 327 ponds, 1,171 irrigation facilities, 193 drinking water supply facilities, 513 hydroelectric power plants, 18 wastewater treatment plants, and 4,471 flood protection facilities. To plan for cities' water needs for 2050 and 2071, 193 drinking water facilities have been constructed to meet the drinking water requirements of all provinces, providing an additional supply of drinking water to 42 million people. To date, 4,522 km of drinking water transmission lines have been laid in various provinces. In addition, within the scope of the Water Supply Project from Türkiye to the Turkish Republic of Northern Cyprus (TRNC), drinking water has been supplied from Mersin's Anamur to the TRNC via a 107 km transmission line, 80 km of which installed under the sea water. In Cyprus, 528 km of main distribution lines and reservoirs have been established to supply spring-quality water (Anatolian Agency, 2024).

The number of dams, which was 276 in 2003, increased to 784 by 2017. A total of 513 hydroelectric power plants with an installed capacity of 15,086 megawatts have been put into operation. The annual energy production, which was 26 billion kilowatt-hours in 2003, has increased nearly fourfold to 95 billion kilowatt-hours, resulting in an annual savings of 11 billion TL in natural gas. To contribute to rural development, agricultural and livestock activities, increase rural employment, and aid in forest fire prevention efforts, 327 ponds have been put into service. With the commissioning of 1,171 irrigation facilities, 6.5 million ha. of the 8.5 million ha. of irrigable agricultural land have been brought under irrigation, providing employment for 1.6 million people and an annual agricultural income increase of 32 billion TL for farmers. Furthermore, water savings have been achieved in agricultural irrigation with pressurized pipeline systems (Anatolian Agency, 2024).

The funding sources for water infrastructure projects are diverse, with user fees and development charges playing a significant role in financing water infrastructure expenditures (Terry et al., 2017). Understanding the financial mechanisms behind water infrastructure funding is essential for ensuring the sustainability of water projects in Türkiye. Moreover, exploring public-private partnership models for funding water services infrastructure can offer innovative financing solutions for water projects in municipalities (Ruiters and Matji, 2016).

In terms of governance and policy frameworks, understanding the impact of central control mechanisms on local water governance is crucial for optimizing infrastructure investments (Habich-Sobiegalla, 2018). Efficient allocation of resources, management commitment and digital inclusion have been identified as significant factors influencing the sustainability of water projects in various regions (Mbogo, 2023). By addressing these aspects, Türkiye can enhance the effectiveness and longevity of its water infrastructure investments.

Moreover, public investments in Türkiye have been a subject of scrutiny regarding their impact on private sector investments and the economy. Studies have explored the crowding-out effect of public debt and public investment on private investment in Türkiye, shedding light on the intricate relationship between public and private sector investments (Serin & Demir, 2023). Understanding these dynamics is essential for policymakers to make informed decisions that balance public spending with private sector growth.

In the context of public investments and regional development, Türkiye has implemented various strategies to stimulate economic growth and reduce income disparities across different regions. Research has examined the role of public investments in fostering regional income per capita convergence, highlighting the potential of public spending as a tool for promoting balanced regional development (Coşkun and Demir, 2022). By assessing the impact of public investments on regional growth, policymakers can tailor their strategies to address disparities and promote inclusive economic development.

Infrastructure development, including water projects, contributes to national advantage, and can enhance service exports in Türkiye (Bilgiç, 2022). By investing in infrastructure, Türkiye can strengthen its economic competitiveness and promote sustainable growth.

In conclusion, public investments in water infrastructure are essential for ensuring water security, promoting sustainable development, and enhancing climate resilience in Türkiye. By leveraging diverse funding sources, engaging local communities, and adopting innovative governance models, Türkiye can optimize its water infrastructure investments for long-term sustainability and economic growth. Engaging local communities in water project planning and implementation can enhance project ownership, increase stakeholder involvement, and ultimately improve project performance and sustainability. Türkiye can benefit from incorporating similar participatory approaches in its water infrastructure development initiatives.

4.2. Public-private partnership initiatives

Public-Private Partnership (PPP) initiatives in the water sector have gained significant attention globally to address challenges in water management and infrastructure development. In the context of Türkiye, where water resources are crucial for various sectors including agriculture, energy, and urban supply, the implementation of PPPs has been a subject of interest and debate. Several studies have highlighted the importance of effective water management practices, especially in the face of climate change impacts, population growth, and increasing water demand (Yaykiran et al., 2019; Kumanlıoğlu, 2019; Yetik, 2023).

The PPP is facilitating the funding and financing of water services infrastructure, particularly at the local government level, to improve service delivery and infrastructure development (Ruiters & Matji, 2016). By engaging with private entities, governments can leverage additional resources and expertise to implement projects more efficiently and effectively. Public capital investments in agricultural water infrastructure have been shown to have a positive impact on economic growth and development (Nhlengethwa et al., 2020).

The debate between public and private water delivery systems and their impact on water tariffs is a topic of interest; it discusses how public ownership historically led to lower water prices, suggesting a transfer of income from taxpayers to users (Bel, 2020). Conversely, argues that private water concessions can introduce profit-seeking behavior that may impact economic, social, and environmental outcomes (Lobina, 2005). Balancing public and private involvement in the water sector is crucial for ensuring affordability and sustainability.

The Turkish government has been actively involved in implementing various strategies to enhance public infrastructure, promote economic growth, and ensure sustainable water management practices. One significant aspect of Türkiye's approach is the utilization of public-private partnerships (PPPs) to leverage private sector resources and expertise in conjunction with public funds to drive infrastructure projects forward. PPP investments have played a pivotal role in boosting energy efficiency in Türkiye, aligning with the country's goals of diversifying its energy mix and enhancing overall energy efficiency (Balcılar et al., 2023).

Türkiye has been actively revising its national political and legal-administrative frameworks related to water management over the past decade, aiming to enhance participation and address challenges in the sector (Baylan, 2016). Despite financial constraints and resource limitations, policy measures such as neighborhood-level responsibility-sharing frameworks and capacity building for local governments have been proposed to enhance water security, particularly in cities like Ankara (Ahsan et al., 2023; Özdemir et al., 2022).

The interconnection between water management and energy sectors underscores the need for integrated approaches and innovative solutions to optimize resource use and minimize environmental impacts (Yüksel, 2015). The effective resource management can enhance resilience and mitigate risks (Eklund & Thompson, 2017; Ak & Benson, 2022).

The role of PPPs in water infrastructure projects has been a subject of interest, with researchers focusing on critical success factors that contribute to the successful execution of such partnerships. Understanding the key factors that enable the effective implementation of PPPs is essential for practitioners and policymakers involved in water supply projects, as these collaborations can leverage private sector expertise and investment to address infrastructure needs (Nguyen et al., 2021). Additionally, the Europeanization of Turkish water policy, despite challenges in accession negotiations, highlights the ongoing efforts to align with EU directives and standards (Demirbilek & Benson, 2019).

In the specific context of irrigation governance and large-scale irrigation projects in Türkiye, studies have highlighted the importance of inclusive policies that promote participation and equitable access to water resources (Mirhanoğlu et al., 2021).

The management of water user organizations and the distribution of water rights among farmers have been key areas of focus, emphasizing the need for transparent and accountable governance structures (Mirhanoğlu et al., 2021). Furthermore, the evaluation of water quality in critical ecosystems like Lake Uluabat underscores the urgency of addressing pollution and eutrophication through collaborative efforts involving public and private stakeholders (Hacısalihoğlu & Karaer, 2018).

The evolving landscape of water management in Türkiye also intersects with broader geopolitical and economic dynamics, as seen in the country's energy trade relations with Europe, and the role of institutions in facilitating cooperation on water and environmental issues (Sakal, 2020). The interconnectedness of water resources across borders, as evidenced in studies on shared river basins, necessitates transboundary collaboration and sustainable management practices (Eklund & Thompson, 2017; Sakal, 2020). The significance of integrated river basin management in enhancing water security and resilience has been highlighted through comparative case studies, emphasizing the need for adaptive strategies and lesson-drawing from diverse contexts (Ak & Benson, 2022).

The synthesis of research on PPP initiatives for water in Türkiye underscores the multifaceted nature of water management challenges and the importance of collaborative approaches involving public and private actors. By leveraging PPPs, optimizing water management practices, promoting regional development through strategic investments, and enhancing healthcare infrastructure, Türkiye can advance its socio-economic objectives and foster inclusive growth across different sectors and regions. Integrating lessons from research studies and international frameworks can guide policymakers in developing robust water management policies that address current challenges and future uncertainties.

4.3. Water tariffs and governmental policy

Tariff structuring is another crucial aspect of water management. Careful consideration of subsidies and tariff design is essential to balance accessibility for the poor with the financial viability of the water sector (Borja-Vega et al., 2019).

Water tariffs play a crucial role in shaping water management practices and influencing consumer behavior. Urban water tariffs are essential tools for achieving economic efficiency, environmental sustainability, and social equity in water resource management (García-Rubio et al., 2015). Through appropriate tariff structures, governments can promote water conservation, ensure cost recovery for water services, and promote equitable access to clean water for all segments of the society. The implementation of progressive tariff policies, as studied in DKI Jakarta, Indonesia, can have significant effects on water management and consumption behaviors. Suratin et al. (2019) analyze the impact of policy interventions, such as progressive tariffs, on water use behaviors, highlighting the importance of policy design in influencing consumer decisions and promoting sustainable water use practices (Suratin et al., 2019). By adjusting tariff structures to incentivize efficient water use, governments can contribute to water conservation efforts and ensure the long-term sustainability of water resources. In the context of residential water pricing policies, the dilemma between increasing block tariffs and uniform tariffs with rebates poses challenges for policymakers. Ma et al. (2018) discusses the multiple goals involved in residential water pricing policies, emphasizing the need to balance social, economic, and ecological impacts when designing tariff structures (Ma et al., 2018).

Pricing policies can influence water consumption patterns, revenue generation for water utilities, and social equity in access to water services, highlighting the complexity of decision-making in water tariff design.

Water tariffs and governmental policy in Türkiye are crucial aspects of the country's water management strategy. The affordability of water and wastewater services is a significant concern, as highlighted by (Ozgun et al., 2018), who conducted a comparative evaluation of tariff affordability ratios across different provinces in Türkiye. This study considered various factors such as water consumption amounts, household sizes, and income levels to calculate the affordability ratio. Understanding these metrics is essential for policymakers to ensure that water tariffs remain accessible to all segments of the population.

In the context of sustainable water resource management, Yaykiran et al. (2019) emphasized the importance of considering the water budget components of river basins, such as the Sakarya River Basin in Türkiye. Sustainable development practices are essential for ensuring the long-term availability of water resources for various uses, including agriculture, industry, and domestic consumption. By utilizing models like the WEAP-PGM model, policymakers can make informed decisions regarding water allocation and usage within river basins.

Türkiye's water management policies have undergone significant changes over the years, impacting the country's resilience to drought events. Eklund and Thompson (2017) highlighted how Türkiye's investments in water infrastructure and regulatory frameworks have positioned it better than neighboring countries like Iraq and Syria to cope with drought impacts. These findings underscore the importance of proactive governmental policies in enhancing water security and mitigating the effects of climate-related challenges on water resources.

The influence of European Union (EU) policies on water management in Türkiye is also evident, as discussed by (Demirbilek & Benson, 2019). The Water Framework Directive (WFD) has influenced Türkiye's water governance structures, leading to a mix of emulation and adaptation of EU norms in national water policies. Understanding the outcomes of policy transfers and the alignment with EU standards is essential for ensuring compliance with international water management frameworks.

Efficient water management in Türkiye is further supported by studies analyzing water tariffs and their role in urban water management policies (Güven, 2024). Understanding the structure of water tariffs is vital for ensuring equitable access to water resources and promoting efficient water use. Additionally, the impact of climate change and global warming on water management underscores the importance of dams, especially for countries like Türkiye facing water scarcity challenges.

Water tariffs of household water usage is differentiated and controlled by municipalities in Türkiye (Table 11). Each metropolitan municipality has a different water tariff; on average, the cost is observed to be 18,83 TL/litre (Sputnik Türkiye, 2024).

Table 12. Water tariffs depending on metropolitan municipalities

Names of Metropolitan Municipalities	Water Tariffs (TL/l)
Adan Metropolitan Municipality	17,85
Ankara Metropolitan Municipality	20,99
Antalya Metropolitan Municipality	18,22
Aydın Metropolitan Municipality	11,46
Balıkesir Metropolitan Municipality	16,36
Bursa Metropolitan Municipality	19,79
Denizli Metropolitan Municipality	11,40
Diyarbakır Metropolitan Municipality	3,80
Erzurum Metropolitan Municipality	23,32
Eskişehir Metropolitan Municipality	22,24
Gaziantep Metropolitan Municipality	25,50
Hatay Metropolitan Municipality	7,63
Istanbul Metropolitan Municipality	23,72
Izmir Metropolitan Municipality	33,13
Kahramanmaraş Metropolitan Municipality	11,01
Kayseri Metropolitan Municipality	22,80
Kocaeli Metropolitan Municipality	22,21
Konya Metropolitan Municipality	20,58
Malatya Metropolitan Municipality	14,03
Manisa Metropolitan Municipality	20,19
Mardin Metropolitan Municipality	13,20
Mersin Metropolitan Municipality	27,15
Muğla Metropolitan Municipality	20,70
Ordu Metropolitan Municipality	21,60
Sakarya Metropolitan Municipality	24,60
Samsun Metropolitan Municipality	16,42
Şanlıurfa Metropolitan Municipality	19,74
Tekirdağ Metropolitan Municipality	22,18
Trabzon Metropolitan Municipality	14,88
Van Metropolitan Municipality	18,33

According to the Water Waste Survey conducted by the Ministry of Agriculture and Forestry in 2021, the drinking water preferences in households are as follows: 31% tap water, 31% water purification devices, and 38% bottled water. According to the striking results of the survey conducted in 26 provinces, representing Türkiye, with 1,200 participants, the average monthly water bill was determined to be 88 TL/month. Despite 81% of the households owning a dishwasher, it was found that one in three people have developed the habit of washing dishes by hand before placing them in the dishwasher. Additionally, 33% of households were found to run the dishwasher without fully loading it, both of which were emphasized as practices that increase water consumption. In 4% of the households surveyed, there were issues with the toilet flushing system, with these households reporting that their toilets had been leaking for approximately four months. Furthermore, 7% of the households had a dripping faucet, with these faucets having been dripping for about three months. Despite nearly all households (98%) owning a washing machine, 67% of the respondents reported using programs with pre-wash, which increases water consumption. Moreover, 43% of participants stated that they run their washing machines without fully loading them, which was highlighted as another factor contributing to increased water usage. 52% of the survey participants stated that they leave the water running while washing their hands, and 22% admitted to doing the same while brushing their teeth. According to the survey results, it can be evaluated that there is insufficient awareness regarding the necessity of water conservation in household water usage, which, in turn, may be reflected in water bills (MoAF, 2024c).

In the realm of water management, Türkiye faces challenges related to water tariffs, sustainability, and efficient resource allocation. Studies have delved into the affordability of water tariffs in different regions of Türkiye, highlighting the importance of evaluating the tariff affordability ratio concerning water and wastewater management sectors (Ozgun et al., 2018). The research provides valuable insights into the economic implications of water tariffs on households and the overall management of water resources in the country.

In the agricultural sector, water pricing and irrigation management play crucial roles in optimizing water use efficiency, discussed the importance of water-saving practices and irrigation pricing approaches in Türkiye's agricultural schemes. By implementing efficient irrigation tariffs and promoting water-saving technologies, policymakers can enhance agricultural productivity while conserving water resources for future generations (Çakmak & Avcı,2017).

The irrigation water tariffs in Türkiye are charged according to the type of irrigation, i.e., gravity and pumped (Table 1). In 2024, the irrigation service fees for irrigation facilities operated by irrigation unions, which will be subject to water usage service fees, have been determined by distributing them according to different groups by DSI. As seen, water tariffs are much higher for pumped irrigation as compared to gravity irrigation, as expected. The water tariffs have different ranges for crop types and irrigation facilities operated by irrigation unions located in different regions. For example, in gravity and pumped irrigation systems, the operation and maintenance fees (TL/decare) have been determined, with the highest fees for the top three crops being banana, rice/sugarcane, and greenhouse and citrus products, respectively. In general, in many parts of the country, irrigation water tariffs are often defined per decare of land cultivated, whereas in some other parts, they are rarely defined per volume of water supplied (MoAF, 2024).

Table 13. Irrigation tariffs in Türkiye

Type of irrigation	Irrigation Water Tariff			
	per decare of cultivated land		per volume of water supplied)	
	(TL/da)	($/da)	(TL/m³)	($/m³)
Gravity	45 - 511	1.36 -15.48	0.17 - 0.29	0.005 - 0.009
Pumped	140 – 1,363	4.24 - 41.29	0.39 - 0.78	0.012 - 0.024

Note: The exchange rate for the currency conversion is based on the date of July 10, 2024

In the context of irrigation governance Mirhanoğlu et al. (2021) emphasized the role of social dynamics in shaping water management practices, by empowering local communities and promoting inclusive decision-making processes, policymakers can enhance the resilience of irrigation systems and improve water resource management.

In conclusion, collaborative efforts between public and private sectors, informed decision-making in tariff design, and targeted investments in infrastructure are essential for addressing water challenges and achieving sustainable development goals. Public investments, public-private partnership initiatives, water tariffs, and government policies in Türkiye shape the country's water management strategies, economic development, infrastructure quality, and environmental sustainability. By considering affordability, sustainability, stakeholder participation, and climate resilience in water policies, Türkiye can ensure the efficient and equitable use of its water resources.

CHAPTER 5. FUTURE WATER RESOURCES MANAGEMENT

5.1. Water demand for the different consumers: agriculture, municipal water supply and sanitation, industry and hydropower

The agricultural sector holds a significant share in Türkiye, as stated in previous chapters. The country's agricultural lands are grouped into categories such as fruit, beverage, and spice crops, fallow land, vegetables, ornamental plants, and cereals-other crop areas, as mentioned in Chapter 3 before. Climate change-induced droughts are profoundly impacting agriculture in Türkiye, particularly in producing cereals, legumes, and fodder crops (MoAF, 2021). Drought has become a major concern in recent years, significantly affecting agricultural output across the country. According to the MoAF (2022), as of May 2021, drought had impacted 41 provinces in Türkiye. During the production season from October to April, rainfall decreased by 23.6% compared to normal levels and by 18.6% compared to previous years. Barley and wheat were among the hardest hit, with wheat alone suffering a yield loss of 2 million tons due to the drought (MoAF, 2022).

Excessive heat directly reduces yields in rainfed agricultural regions, while even in irrigated areas, plants experience heat stress that diminishes their productivity. Changes in rainfall patterns, temperature, and radiation are altering the phenological stages of plants, leading to earlier harvest dates. This shortened growth period, negatively affects crop quality and yield, impacting factors such as grain filling, the number of grains per spike, and grain weight. Additionally, fruit trees face heightened risks from late frosts due to early flowering, which results in premature fruit ripening and a decline in fruit quality. Overall, the rising temperatures across Türkiye are affecting the phenological stages, productivity, and overall production of crops.

Between 2010 and 2021, Türkiye experienced frequent meteorological natural disasters, with storms, heavy rainfall, floods, and hailstorms being the most common (TSMS, 2021). These natural disasters pose significant challenges to agriculture, often causing extensive damage to crops, orchards, and greenhouses. The disruption of plant growth and development leads to substantial yield losses and financial hardships for farmers. The timing of these events can further exacerbate their impact; for instance, hailstorms during critical growth stages such as tillering, stem elongation, or flowering can devastate grain and fruit crops. Moreover, extreme weather events contribute to soil erosion, nutrient loss, and long-term degradation of agricultural land.

In Türkiye, the primary policies of relevant authorities focus on several key goals: enhancing quality, production, and trade; ensuring supply security; protecting public health and consumer interests; increasing the competitiveness of the food, agriculture, and forestry sectors; efficiently utilizing ecological resources; addressing climate change and its impacts; and conducting necessary studies in these areas (MoAF, 2022). The Ministry of Agriculture and Forestry's Strategy Action Plan (2018-2022) includes responsibilities such as implementing services related to drought, agricultural environment, desertification, other agricultural disasters, and agricultural insurance. It also helps farmers affected by natural disasters in accordance with specific legislation.

With the increasing population in Türkiye, the per capita annual available water potential is expected to decrease to 1,200 m^3/person by 2030, 1,116 m^3/person by 2040, and 1,069 m^3/person by 2050. These figures indicate that Türkiye will become a more water-scarce country.

Climate change poses significant challenges to industrial water use and management in Türkiye, particularly in terms of water availability, quality, and sustainability. One area that highlights the vulnerability of water resources to shifting climatic conditions is the Küçük Menderes River Basin in Western Türkiye. According to Yağbasan (2016), the impact of climate change on groundwater recharge rates in this region is a clear indication of these challenges. As temperatures rise and precipitation patterns change, the recharge rates of groundwater sources are altered, creating difficulties for industries that depend on these sources for various processes. The resulting variability in water availability threatens not only the continuity of industrial operations but also the long-term sustainability of water resources in these regions.

Due to the climate change, the manufacturing sector, especially electronic-electrical products, petroleum and coal, non-metallic minerals, and food and chemicals, faces significant challenges. Real estate and construction are vulnerable to wildfires, floods, and storms, while chemical production is particularly impacted by water stress (ICoI, 2024).

The primary goal of the IPPC approach is to protect the environment by preventing or, when prevention is not possible, reducing emissions of air, water, and soil pollutants from industrial activities with high pollution potential. This integrated approach includes waste prevention/reduction at the source, the application of Best Available Techniques (BAT), assessment according to environmental quality standards, and energy and resource efficiency. To promote the adoption of the IPPC approach in Türkiye, the MoEUCC is implementing IPPC harmonization and sectoral projects (ICoI, 2024).

In the Specific Sector, Clean Production Practices (BESTÜ) Project carried out by Middle East Technical University (METU) for the MoEUCC, studies were conducted on Best Available Techniques (BAT) in the textile and leather processing sectors. The project involved creating drafts of the IPPC Notices based on data collected from 52 enterprises and preparing sectoral guidelines. These guidelines serve as a crucial resource for improving wastewater management and environmental performance in these sectors (ICoI, 2024).

A project conducted by TUBITAK Marmara Research Center (MAM) between 2014 and 2017 assessed the potential for resource efficiency in industries. It identified effective and sustainable uses of raw materials, energy, and water in five selected manufacturing sectors in Türkiye. The Industrial Water Use Efficiency Project, categorized by NACE Codes, aims to create a roadmap for improving water use efficiency in water-intensive industrial facilities. The project involved selecting representative facilities from various sectors, examining water use and wastewater quantities, and evaluating existing water efficiency practices (ICoI, 2024).

The Adaptation Policies section of the Climate Change and Water Resources Project outlines strategic recommendations for mitigating the impact of climate change on industrial water use. This section evaluates adaptation activities across various sectors and compiles examples from different regions. Identifying and prioritizing sectors that are particularly vulnerable to climate change in Türkiye is essential. To address this, the project selected 12 key sectors based on international practices to reflect Türkiye's specific needs (MoAF, 2016). These sectors are categorized for evaluating adaptation efforts and include health, agriculture, food security, forestry and biodiversity, water resources, infrastructure (buildings, transportation, and energy), Urban and Basin Planning, Coastal Areas, Marine Environment and Fisheries, Tourism, Industry-Commerce and Energy, Research and Development, Information, Education, and Training, and Financing and Insurance (ICoI, 2024).

The "Impact of Climate Change on Water Resources" project is a comprehensive study aimed at assessing how climate change affects both surface and groundwater resources in Türkiye and identifying adaptation strategies on a river basin basis. The study covers the period from 2015 to 2100 and initial climate projections were based on outputs from three global models outlined in the IPCC's 5th Assessment Report and the RegCM4.3 regional climate model, using the RCP 4.5 and RCP 8.5 emission scenarios (MoAF, 2016).

The project involves simulations to generate projections for eight parameters and seventeen climate indices at the basin scale. These projections, compared to a 1971-

2000 reference period, were calculated as seasonal and annual averages for 10-year and 30-year intervals, extending to 2100. This initiative is notable for providing Türkiye's first results using three global climate models at a resolution of 10 x 10 km, with calculations based on atmospheric CO2 concentrations of approximately 1,370 ppm under the RCP 8.5 scenario and 650 ppm under the RCP 4.5 scenario (MoAF, 2016).

As stated in Chapter 3 earlier, a sectoral impact analysis was conducted, developing a methodology to evaluate climate change effects on crucial sectors including drinking and utility water, agriculture, industry, ecosystems, tourism, and energy for Türkiye. This analysis considered climate projections for three pilot basins and categorized impact severity into "low," "medium," "high," and "very high" (MoAF, 2016).

The simulations indicate significant warming trends in Türkiye from 2015 to 2100, with increased temperatures observed on both seasonal and annual scales. Although early years may show minor temperature variations, a significant rise in temperatures is expected as greenhouse gas emissions increase. Winter temperatures are projected to be at least 1°C higher after 2050 compared to the 1970-2000 baseline, with the most pronounced increases occurring in summer and spring. By the 2100s, temperatures in eastern and southeastern Türkiye are anticipated to rise by 4-6°C.

Rising daytime temperatures are likely to lead to more frequent and severe heatwaves, with higher nighttime temperatures exacerbating the effects and increasing energy demand for cooling. The combination of anticipated rainfall shortages and higher evaporation rates will further stress water resources and the agricultural sector. The tourism industry along the Mediterranean coast may also face significant challenges (MoAF, 2016).

Model simulations suggest that northern basins in Türkiye will experience increased rainfall compared to the reference period. However, the RCP 8.5 scenario predicts worsening drought conditions in southern basins from the 2050s onwards, with significant reductions in annual rainfall, particularly in the Konya Closed Basin. Rainfall decreases are projected to be between 12% and 25% by the century's end, depending on the scenario. The project also includes hydrological projections, assessing water potential across all basins with a unified hydrological model. It converts precipitation data into flow values to evaluate surface and groundwater resources under current and projected conditions. The Meriç-Ergene and Euphrates-Tigris basins are the least affected, while the Asi Basin, and to a lesser extent the Burdur, North Aegean, Western Mediterranean, and Akarçay basins, experience the most significant impacts (MoAF, 2016).

Hydrological projections forecast a decrease in total flow across Türkiye, with the HadGEM2-ES model predicting a 40-45% decline in median gross water potential by 2100 compared to the reference period, while the MPI-MSM-MR model forecasts a 15-20% reduction. The Euphrates-Tigris, Eastern Mediterranean, and Konya Closed Basins are expected to face the most severe water deficits, with the Konya Closed Basin experiencing precipitation reductions of 10 to 30 mm under the RCP4.5 scenario (MoAF, 2016). Climate change poses significant risks to Türkiye's vital tourism sector, therefore The DSI initiated an Emergency Drinking Water Project in 2011, aiming to ensure a sustainable drinking water supply to the Bodrum Peninsula by 2040. The growing water scarcity in the Konya basin underscores the urgent need for sustainable water management practices to tackle the challenges posed by both climate change and industrial activities in Türkiye.

Understanding these evolving streamflow trends is crucial for developing adaptive strategies to mitigate the impact of climate change on water availability and quality in industrial areas.

The Water Risk R&D Project, a collaboration between the Business World and Sustainable Development Association (SKD Türkiye) and ENSTİTÜSU, focuses on using sensor technology to measure water efficiency in wheat production. This project is conducted in Çerikli, Kırıkkale Delice district, one of Türkiye's driest regions. It aims to track key performance indicators (KPIs), assess water risks, perform economic analyses for modern irrigation methods, and disseminate the project results. The total area of 11,58 decares has been divided into seven different plots. For comparison purposes, one area was used for farmer practices where the irrigation method, amount, and frequency were left to the farmer's discretion. In the other four areas, the sprinkler and drip irrigation programs were implemented. The last two ones were reserved for dry farming and sensor calibration activities. Given the adverse climate conditions and water scarcity in the project's region, coupled with Türkiye's increasing food security needs and the strategic importance of wheat, it is evident that the commonly practiced dry farming is insufficient. Increasing irrigation practices is necessary to enhance yields. The project demonstrated that using sprinkler and drip irrigation resulted in yield increases of up to 40% compared to dry farming. Additionally, drip irrigation in the project area saved 20% more water compared to sprinkler irrigation. When compared to the farmers' practices, the project achieved water savings of 53% with sprinkler irrigation and 65% with drip irrigation. Additionally, the use of sensor technology allowed for more precise irrigation scheduling and application. Irrigation was monitored in real-time and adjusted based on plant water needs and rainfall, improving water use efficiency. The project results revealed that, promoting smart farming practices is vital in the face of water stress and scarcity exacerbated by climate change.

As demonstrated, the investigations among the 12 priority key crops, maize and wheat are highly vulnerable to drought as a consequence of climate change (Pilevneli et al., 2023).

A recent study by Coskun Dilcan (2023) investigated the relationship between water and electricity generation under various climate change scenarios in the context of water-electricity-climate nexus. The study evaluates basin-based and country-wide water consumption and the water intensity of electricity production which aims to provide new tools and methods to inform policy and ensure sustainable water and electricity management for Türkiye in the future. According to the climate change scenario applications on the electricity sector related to water resources, the HadGEM-4.5 climate scenario gave the highest hydroelectric power plant water consumption and water intensity recorded at $4{,}393\times10^{6}$ m^3 and 85,487 m^3/GWh in 2053, while the GFDL-4.5 had the lowest value at $2{,}609\times10^{6}$ m^3 and 50,768 m^3/GWh, respectively. Additionally, for the HadGEM 8.5 climate scenario, the largest water consumption by fossil-fueled power plants was recorded in Türkiye at $246x10^6$ million m^3 and water intensity as 1,146.2 m^3/GWh. And the highest total water consumption and intensity of power plants in Türkiye were seen at $4,635x10^6$ m^3 and 17,450.7 m^3/GWh for the HadGEM 4.5 climate scenario in 2053, respectively. The highest basin-based water consumption per basin area (BBWC) results were seen at Fırat-Dicle, Ceyhan and Kızılırmak Basins in 2053 at HadGEM 4.5 scenario, while Dogu Karadeniz, Aras and Dogu Akdeniz Basins have the lowest BBWC. The study highlights the importance of integrated water management in Fırat-Dicle, Ceyhan and Kızılırmak Basins especially in sectoral water usages.

Türkiye's future water resources management is at a critical juncture due to the increasing demand for water and the impacts of climate change. The country's existing water resources are under pressure from growing demands in areas such as population growth, urbanization, and especially agricultural irrigation. In addition, changes in precipitation patterns are causing imbalances in the seasonal and regional distribution of water resources. The fact that water losses and leakages are still at high levels poses a significant obstacle to effective water management. In Türkiye's water resources management, it is of vital importance to take strategic steps such as protecting existing resources, increasing water efficiency, and promoting technologies that ensure water conservation.

5.2. Adaptation measures for protection and rational use of freshwater resources

In Türkiye since 2016, efforts have focused on integrating River Basin Management Plans with upper-level plans and natural resource strategies, alongside sectoral water allocation projects (TAGEM, 2021). Basin Management Committees and Provincial Water Management Coordination Committees have assessed water resource management across 25 river basins.

The European Green Deal aims for climate neutrality by 2050, influencing Türkiye's Green Deal Action Plan, which includes initiatives like wastewater reuse and a national water footprint guidance (MoAF, 2023 a). Türkiye is also drafting a comprehensive 'Water Law' to ensure sustainable water management and alignment with the Water Framework Directive.

The 'National Water Plan' of 2019 outlines policies for basin-based management and water resource efficiency, stressing the urgent need to finalize the new water law. This need was reaffirmed in the '1st Water Council' in October 2021 (MoAF, 2021 b).

Türkiye's earlier National Development Plans (8-th and 9-th) included water management targets, leading to the 10-th National Development Plan (2014-2018), which focuses on establishing centralized monitoring for water storage and irrigation. Electronic measurement systems have been installed in storage and irrigation facilities to monitor water use effectively (TAGEM, 2021).

The "Türkiye Agricultural Drought Management Strategy and Action Plan" considered key topics, including irrigation planning, water investments in dry and irrigated agricultural areas, climate-friendly farming techniques, plant and seed diversity, pest and disease control, economic and social support, pasture grazing plans, land use plans, and the implementation of emergency actions (MoAF, 2022).

Since 2016, the General Directorate of Water Management has implemented Sectoral Water Allocation Plans to optimize water use considering economic, social, and environmental factors (TAGEM, 2021).

As discussed in earlier chapters, Türkiye has established forward-looking goals and strategies to promote water efficiency across all water-using sectors. Under the Water Efficiency Mobilization initiative, the Ministry of Agriculture and Forestry has developed the "Water Efficiency Strategy Document and Action Plan (2023-2033)" to adapt to the changing climate (MoAF, 2023a). Within the framework of Türkiye's Water Efficiency Mobilization, the goal is to achieve up to 50% water savings in the industrial sector by enhancing water use efficiency and expanding the adoption of efficiency measures (Istanbul Chamber of Industry, 2024). As of 2021, the reuse rate of treated wastewater in Türkiye was 2.5%. However, recent projects have increased this rate, and the 4% target set for 2022 was achieved by July of that year. According to the Ministry of Environment, Urbanization, and Climate Change, the aim is to raise the treated wastewater reuse rate to 5% by 2023 and 15% by 2030 (ICoI, 2024).

Türkiye's National Climate Change Adaptation Strategy and Action Plan focuses on key sectors such as water management, agriculture, and food security, supported by scientific studies. The plan outlines five priority goals for agriculture: integrating climate adaptation into policies, enhancing research, promoting sustainable water use, protecting soil and biodiversity, and improving institutional capacity and cooperation. The plan seeks to develop integrated low-carbon, climate-resilient agricultural systems to ensure sustainable food security and ecosystem health. Key methods include climate-smart agriculture, efficient irrigation practices, soil moisture conservation, and reducing CO_2 emissions through practices like reduced tillage. Additionally, direct seeding and windbreaks are promoted to combat soil erosion, while effective fertilization techniques, such as using animal manure and slow-release fertilizers, are emphasized as crucial for both adaptation and mitigation (MoAF, 2021a).

In Türkiye, irrigated land area has reached up to 7.1 million ha. in total, in 2023 (DSI, 2023), and it is aimed to be enlarged to 8.6 million ha. in the future. In agricultural irrigation, which is a major water use sector, efficiency improvements aim to raise irrigation efficiency from 50.4% in 2021 to 60% by 2030 and 65% by 2050 in this context. Training programs for modern irrigation techniques and the use of solar energy systems are provided to farmers, alongside extension materials and digital platforms to support learning and implementation (TAGEM, 2021).

To address water loss and leakage in Türkiye, steps have been taken in line with the EU Water Framework Directive. The Ministry of Agriculture and Forestry has incorporated measures into the 10-th Development Plan and relevant action plans by Development Agencies. These plans emphasize preventing water losses and leaks and promoting the use of environmentally friendly materials through network improvements. A key measure is the "Regulation on the Control of Water Losses in Drinking Water Supply and

Distribution Systems", which mandates municipalities to reduce water loss and leakage to 25% over ten years. Projects aimed at improving "Water Distribution and Control Systems" are expanding in cities like Istanbul, Denizli, Sakarya, and Kayseri (GSL, 2024).

In Türkiye, urban water efficiency is analyzed through various factors, including water supply, treatment, and reuse. The goal is to minimize losses, improve operational efficiency, and reduce the 33.54% water loss rate in 2021 to 25% by 2033 and 10% by 2040. The 11-th National Development Plan (2019-2023) emphasizes improving water use efficiency, accelerating institutional reforms, and increasing irrigation infrastructure investment. It also focuses on reusing treated wastewater and reducing pressure on water resources (TAGEM, 2021).

The "Climate Change and Water Management: Industrial Sector Report", highlights that industries with specific water consumption levels close to the lower limits of Clean Production (CP) standards could achieve additional water savings of 20-90% through greywater recovery, rainwater harvesting, or sector-specific CP practices (ICoI, 2024). To achieve water savings in processes where water is used, it's essential to implement water efficiency-focused approaches alongside water treatment and recycling. Various applications can help optimize water usage, including high-pressure, low-volume hose nozzles, automatic shut-off systems, low-water-consumption sprays, and spray balls for tank cleaning. Additionally, alternatives like steam and ultrasonic cleaning can replace traditional hot water washing methods, further reducing water consumption (NuWater, 2024).

The concept of water resilience also extends to communities and ecosystems. Protecting and restoring natural ecosystems, such as wetlands and forests, can enhance their ability to absorb and buffer the impacts of extreme weather events. Communities will need to be empowered with the knowledge and resources to manage their water sustainably, especially in vulnerable regions where the effects of climate change are likely to be most severe.

As of 2021, the rate of treated wastewater reuse in Türkiye is 2.5%. However, with the implementation of recent projects, this rate has increased. The 4% target set for 2022 was achieved by July 2022. According to the projections of the MoEUCC, the goal is to increase the rate of treated wastewater reuse to 5% by 2023 and to 15% by 2030 (ICoI, 2024).

In Türkiye, potential adaptation measures that can be taken against climate change include reducing loss and leakage rates in drinking water supply, implementing rainwater harvesting, using water-saving fixtures in showers and toilets, and reusing domestic wastewater. It is necessary to adapt crop pattern suitable for climate change, completely abandon flood irrigation, promote drip irrigation, apply deficit irrigation and adopt organic farming and good agricultural practices, improving irrigation efficiency and raising farmer awareness. For industrial facilities, promoting clean production practices, enhancing internal controls, establishing a zero-discharge approach, and recovering wastewater for reuse in processes and similar applications are essential (Capar, 2019).

CHAPTER 6. CONCLUSIONS

6.1. Future water management for sustainable development

As the global population continues to grow, and climate change exacerbates the scarcity of natural resources, water management is emerging as one of the most pressing challenges of the 21st century. Future water resources management globally, as well as in Türkiye will require a multifaceted approach that leverages technological advancements, sustainable practices, and cooperative governance to ensure that water remains accessible, clean, and equitably distributed.

Climate change is expected to intensify water-related challenges, with more frequent and severe droughts, floods, and extreme weather events. Future water management strategies must prioritize resilience, focusing on adaptive measures that can withstand these unpredictable changes. This includes building resilient infrastructure, such as flood defenses and drought-resistant reservoirs, and developing flexible policies that can be adjusted as conditions change.

With the swift rise in global population, there is an accompanying surge in the demand for food. At the same time, economic advancement and rising incomes have expanded people's ability to access a wider range of food options. Urbanization has further accelerated this trend by boosting consumer demand for processed foods. Shifts in lifestyle and dietary habits have shifted consumption patterns towards more processed and convenience foods, further increasing food demand. As a result, the escalating need for food production on a global scale has introduced new challenges for ensuring food security. In this context, implementing water-saving irrigation techniques, such as drip and sprinkler systems, is crucial as they minimize water wastage and enhance efficiency. Advanced irrigation technologies, including precision irrigation and soil moisture sensors, help to accurately match water application with plant requirements, reducing excess and optimizing usage. Soil and water management practices also play a critical role; improving soil's water-holding capacity and preventing erosion can significantly impact water efficiency. Additionally, adopting integrated water management approaches that consider the entire water cycle, from rainfall collection and storage to irrigation and runoff management, ensures that water resources are used sustainably. By embracing these practices, agricultural operations can improve productivity, conserve water, and adapt to changing environmental conditions.

In today's rapidly urbanizing world, the sustainable management of water resources has become an increasingly critical challenge. As urban populations grow, the pressure on infrastructure and natural resources intensifies, making the need for efficient, reliable, and sustainable access to clean water paramount for both public health and economic development. The concept of "Smart Water Cities" offers a strategic approach to address these challenges through the integration of innovative technologies and comprehensive management systems. Smart Water Cities harness advanced technologies, data-driven insights, and sustainable practices to enhance water management across urban environments. These initiatives aim to optimize water distribution and quality while building resilience against water-related challenges, such as scarcity, pollution, and aging infrastructure. By utilizing real-time data analytics and monitoring through sensors and IoT devices, authorities can track usage patterns, promptly detect leaks, and accurately predict demand fluctuations. Cities should also shift their focus towards nature-based solutions and green infrastructure as a strategy to improve sustainability and bolster resilience against climate change, moving away from traditional methods that often prove inadequate or costly under evolving climate conditions. Nature-based solutions encompass a variety of green infrastructure elements such as urban green spaces, forests, wetlands, and marshes. These natural systems not only help in reducing disaster risks and adapting to climate impacts but also function as significant carbon sinks, thereby contributing to climate mitigation.

Groundwater management is a key consideration for industrial water use, with depletion in many regions necessitating sustainable management practices to meet the demands of agriculture, industry, municipal supply, and ecosystems. Subsurface storage management offers a viable option to address water scarcity and ensure the sustainable use of groundwater resources. By integrating groundwater management into industrial water practices, industries can enhance water security and resilience in the face of climate change impacts. Effective water management in this sector is vital for sustainable operations and reducing water consumption, thereby enhancing social welfare and ecosystem health. Thus, responsible water use is essential for maintaining industry sustainability and addressing environmental concerns.

The significance of the water footprint in supply chain management has increasingly become a focus for leading companies, with many incorporating water stewardship into their corporate social responsibility agendas. This growing awareness reflects a broader recognition of the need for sustainable water management practices. Effective management of water resources not only supports environmental sustainability, but also contributes to profitability across various industries. Sectors such as food and beverage production are highly dependent on efficient water usage and wastewater management to achieve sustainable production. The adoption of water-efficient practices and technologies is crucial for minimizing water waste and ensuring the sustainability of production processes.

In process industries, optimizing both processes and the integration of water and energy management is critical for achieving both profitability and sustainability. Water, being a fundamental resource for economic growth and human survival, plays a pivotal role in balancing production benefits with risk control, particularly under the framework of the water-energy nexus. This nexus highlights the interdependence between water and energy systems, emphasizing that efficient management of these resources is essential not only for industrial development but also for overall sustainability. As industries seek to enhance their operational efficiencies, integrating water and energy strategies becomes crucial, ensuring that resource use is optimized and that environmental impacts are minimized.

6.2. Policy recommendations for the future use and management of water resources in Türkiye

In Türkiye, effective agricultural water management is crucial for ensuring sustainable food production and addressing the challenges posed by water scarcity. Given the country's diverse climate and varying regional water needs, a comprehensive approach to managing agricultural water resources is essential. This involves implementing advanced irrigation technologies, optimizing water use efficiency, and integrating practices such as rainwater harvesting and wastewater recycling. By focusing on precision agriculture and adopting water-saving technologies, farmers can enhance crop yields while minimizing water consumption. Additionally, regional and local water management strategies should be tailored to address specific challenges, including droughts and seasonal variations. Collaborating with stakeholders, including governmental bodies, agricultural organizations, and local communities, is vital for developing and enforcing effective water management policies. Strengthening infrastructure, investing in research and development, and promoting education and awareness about sustainable practices are also key components. Through these efforts, Türkiye can achieve a balance between agricultural productivity and water conservation, securing its water resources for future generations while supporting its agricultural sector.

In Türkiye, the promotion of renewable and clean energy sources is essential. The integration of water management practices with clean energy initiatives is important for reducing environmental impacts and ensuring the sustainability of energy production. By aligning water and energy policies, Türkiye can achieve synergies that benefit both sectors while minimizing resource conflicts and environmental degradation.

The transition to green energy and climate change mitigation is essential for environmental, economic, and social well-being. Adopting zero waste principles is a vital step in this transition. The circular economic model, which prioritizes recycling and efficient waste management through the "3R including reduce, reuse, recycle" approach, plays a key role in this effort. Given its placement in the climate-sensitive Mediterranean Basin, Türkiye must harness strategies for greenhouse gas emission reduction. Various Turkish institutions, including local governments, are actively engaged in projects aimed at combating climate change. Türkiye's commitment to the Paris Agreement, with a target of achieving net-zero carbon emissions by 2053 and embracing a green development framework, has far-reaching implications. Effectively executing climate mitigation and adaptation strategies will not only improve climate resilience, but also promote green growth. Planning for future green is a crucial responsibility, serving both present and future generations.

Effective water and wastewater management in the industry involves several essential considerations. Initially, it is important to establish a comprehensive "Water Balance" or "Water Budget," which entails a detailed assessment of the facility's water requirements and wastewater characteristics. Utilizing tools such as the "Industrial Water Use Efficiency Project by NACE Codes" can help identify potential water efficiency improvements by comparing the best available techniques (BAT) with current water consumption levels.

Water efficiency measures should be organized into categories, including in-plant control, advancements in production technologies, and enhanced treatment and reuse practices. BAT should be applied to both production and support processes without compromising product quality. Additionally, the reuse of treated wastewater for non-industrial purposes should be supported by gaining social acceptance from employees. Economic feasibility studies of these measures are essential and should guide the development of water efficiency strategies. Implementing these strategies effectively will improve the facility's overall water management. Achieving this, requires a multidisciplinary approach, incorporating economic analysis and supply chain evaluations to optimize resource utilization and advance towards sustainable production. Promoting effective water management and exploring green finance options are critical for reducing the corporate carbon footprint and advancing circular economy objectives.

To minimize their water footprint, companies need to tackle water-related challenges from multiple angles: social, economic, and environmental. This includes evaluating water consumption and associated risks throughout their supply chains, addressing impacts in regions experiencing water scarcity, endorsing agreements to improve water access, and working with a range of stakeholders to promote water sustainability. In Türkiye, especially in water-intensive areas such as Istanbul with its varied water resources, integrated water management strategies are essential for mitigating the effects of climate change on industrial water use. Tools, such as the Soil and Water Assessment Tool (SWAT) can be instrumental in analyzing the impacts of climate and land-use changes on water resources, thereby guiding effective and sustainable water management practices across the country.

Policy interventions and adaptation strategies in Türkiye recognize the limited research on the socio-economic impacts and costs of adapting to climate change, emphasizing the necessity for interventions in water resources management to tackle climate-induced challenges. With potential impacts on water availability, agriculture, natural disasters, and freshwater ecosystems, climate change requires proactive measures to ensure the resilience of industrial water management practices in Türkiye.

The evaluation of water security effectiveness in integrated river basin management is vital for addressing climate change impacts on water resources in Türkiye. With escalating water scarcity, population growth, and industrial activities, optimizing institutional arrangements for water management is crucial to ensure the sustainability of water resources amidst climate change challenges.

Public participation and community engagement will also be critical in future water management. Ensuring that local communities are involved in decision-making processes can lead to more effective and equitable outcomes. Additionally, educating the public about water conservation and the impacts of climate change can foster a culture of stewardship, by encouraging more sustainable water use at all levels of society. The integration of sequential data assimilation techniques for streamflow forecasting and sensitivity analysis to uncertainties in hydrological models highlights the growing need for advanced tools and approaches to manage water resources effectively in urban environments. Moreover, future scenarios modeling of water management responses to climate change underscores the importance of proactive planning to address the evolving challenges in water systems.

The management strategies for the 25 basins in Türkiye should prioritize climate change considerations, with continuous monitoring and enhancements being integral. Alongside basin-specific plans, it is essential to develop and implement management strategies at both provincial and regional levels. Effective governance can be achieved through robust collaboration among industry leaders and stakeholders, which will improve engagement in water management decision-making processes.

In Southeastern Anatolia, where the impacts of rising temperatures and potential heatwaves are significant, it is critical to formulate drought response strategies for the period from 2015 to 2100. This includes promoting afforestation, conserving water resources, and increasing public awareness about climate change impacts. Addressing potential adverse effects requires scientific evaluation of their impacts on agriculture, livestock, and public health, followed by the implementation of targeted measures.

Given that the Euphrates and Tigris rivers are shared transboundary water resources, it is important to establish information-sharing protocols with neighboring countries to avoid disputes and promote collaborative solutions. Residents in Southeastern and Eastern Anatolia need to be updated on changes in precipitation patterns and river flow. Research into high-value crops and strategies to safeguard pasture livestock farming is essential considering anticipated vegetation shifts. Additionally, areas such as the Eastern and Western Black Sea regions and the Çoruh Basin, which face increased rainfall and risks of flooding and landslides, require protective measures and public education initiatives. To effectively manage anticipated water scarcity, it is crucial to strengthen public administration, promote efficient water use practices, and enhance coordination among universities, public institutions, and civil society.

Effective water management in the future will require robust governance frameworks that promote transparency, accountability, and cooperation. As water resources often span political boundaries, transboundary water management will become increasingly important. International agreements and regional cooperation will be essential to manage shared water resources equitably and sustainably, preventing conflicts and ensuring that all stakeholders have a voice in decision-making.

Sustainability will be the cornerstone of future water management strategies. This includes the adoption of water-efficient practices in agriculture, industry, and urban planning. Precision agriculture, for instance, can significantly reduce water usage by applying the right amount of water, fertilizer, and pesticides precisely where and when they are needed. Urban areas will need to invest in green infrastructure, such as permeable pavements and rain gardens, to enhance groundwater recharge and reduce stormwater runoff.

IWRM will become increasingly important, requiring the coordination of water, land, and related resources across sectors and scales. This holistic approach ensures that the needs of all stakeholders like agricultural, industrial, domestic, and environmental etc. are balanced, minimizing conflicts and maximizing the sustainable use of water resources.

Effective water resources management is essential for addressing the complex and interconnected challenges faced by water systems today. By integrating technological advancements, sustainable practices, and robust policy frameworks, we can work towards ensuring the long-term availability and quality of water resources. The collective efforts of governments, industries, and communities are crucial in achieving a sustainable water future and addressing the diverse impacts on water resources. The path forward involves a collaborative approach that combines innovation, regulation, and community engagement to manage water resources effectively and ensure their sustainability for future generations.

References

Abrams, A., Carden, K., Teta, C., & Wågsæther, K. (2021). Water, sanitation, and hygiene vulnerability among rural areas and small towns in south africa: exploring the role of climate change, marginalization, and inequality. Water, 13(20), 2810. https://doi.org/10.3390/w13202810

Ahsan, M., Tanrıvermiş, Y., & TUNA, M. (2023). Water security challenges of Ankara city in Türkiye: lessons from climate change impact and the covid-19 pandemic. World Water Policy, 9(2), 204-220. https://doi.org/10.1002/wwp2.12099

Ak, M. and Benson, D. (2022). Assessing the water security effectiveness of integrated river basin management: comparative case study analysis for lesson-drawing. Frontiers in Water, 4. https://doi.org/10.3389/frwa.2022.1013588

Akkaya C., Efeoğlu A., Yeşil N. 2006, "Avrupa Birliği Su Çerçeve Direktifi ve Türkiye'de Uygulanabilirliği", TMMOB Su Politikaları Kongresi, 21-23 March 2006. https://eskisakarya.imo.org.tr/resimler/ekutuphane/pdf/9125.pdf

Anatolian Agency (2024). A total of 125.8 billion TL has been invested in Türkiye's water resources. https://www.aa.com.tr/tr/Türkiye/Türkiyenin-su-kaynaklarina-125-8-milyar-liralik-yatirim/1094990#:~:text=Bu%20eserlerin%20508'ini%20baraj,125%2C8%20milyar%20lira%20oldu

Atçı, E. B. (2020). Türkiye Genelinde Su Kaynaklarının Durumu. Su ve Çevre Teknolojileri Dergisi, Yıl: 15, Sayı: 139, s. 32, İstanbul.

https://www.suvecevre.com/edergi/19/139/38/index.html#zoom=z

Avcı, İ., 2021. Dünya'da Ve Türkiye'de Su Politikaları Ve Su Yönetimi. İstanbul Bülten, no 168. https://istanbul.imo.org.tr/Eklenti/342,sayi168-makale1pdf.pdf?0

Babaoğlu, C. (2023). Türkiye's sustainable water policies and planning initiatives as part of climate change action. Present Environment and Sustainable Development, (1), 95-106. https://doi.org/10.47743/pesd2023171007

Balcılar, M., Uzuner, G., Nwani, C., & Bekun, F. (2023). Boosting energy efficiency in Türkiye: the role of public–private partnership investment. Sustainability, 15(3), 2273. https://doi.org/10.3390/su15032273

Baylan, E. (2016). Türkiye'de katılımcı su yönetimi için zorlukların ve fırsatların i̇ncelenmesi. Yüzüncü Yıl Üniversitesi Tarım Bilimleri Dergisi, 26(1), 106-117. https://doi.org/10.29133/yyutbd.236427

Becher, O., Pant, R., Verschuur, J., Mandal, A., Paltán, H., Lawless, M., ... & Raven, E. (2023). A multi-hazard risk framework to stress-test water supply systems to climate-related disruptions. Earth's Future, 11(1). https://doi.org/10.1029/2022ef002946

Bel, G. (2020). Public versus private water delivery, remunicipalization and water tariffs. Utilities Policy, 62, 100982. https://doi.org/10.1016/j.jup.2019.100982

Bilgiç, E. (2022). Infrastructure as a determinant of national advantage in service export: the case of türki̇ye. Uluslararası İktisadi Ve İdari İncelemeler Dergisi, (37), 89-102. https://doi.org/10.18092/ulikidince.1134247

Borgomeo, E. (2022). Water Resource System Modelling for Climate Adaptation. In: Kondrup, C., et al. Climate Adaptation Modelling. Springer Climate. Springer, Cham. https://doi.org/10.1007/978-3-030-86211-4_17

Borja-Vega, C., Morales, E., & González, J. (2019). Incidence of subsidies in residential public services in Mexico: the case of the water sector. Water, 11(10), 2078. https://doi.org/10.3390/w11102078

Bouramdane, Ayat-Allah (2023). Optimal Water Management Strategies: Paving the Way for Sustainability in Smart Cities. Smart Cities 6, no. 5: 2849-2882. https://doi.org/10.3390/ smartcities6050128

Calò, F., Notti, D., Arnedo, J., Abdikan, S., Görüm, T., Pepe, A., ... & Şanlı, F. (2017). DinSAR-based detection of land subsidence and correlation with groundwater depletion in Konya Plain, Türkiye. Remote Sensing, 9(1), 83. https://doi.org/10.3390/rs9010083

Capar, İklimİN Projesi İklim Değişikliği Eğitim Modülleri Serisi, Modül 8, Su Kaynakları Yönetimi ve İklim Değişikliği,1-40, 2019.

Chang, H., Bonnette, M. (2016). Climate change and water-related ecosystem services: impacts of drought in California, USA. Ecosystem Health and Sustainability, 2(12). https://doi.org/10.1002/ehs2.1254

Clemenz, N., Boakye, R., & Parker, A. (2019). Rapid climate adaption assessment (rcaa) of water supply and sanitation services in two coastal urban poor communities in accra, ghana. Journal of Water and Climate Change, 11(4), 1645-1660. https://doi.org/10.2166/wcc.2019.204

Coşkun, N. and Demir, E. (2022). Club convergence: do public investments play a role in regional income per capita convergence in Türkiye? Ege Akademik Bakis (Ege Academic Review), 22(3), 32-43. https://doi.org/10.21121/eab.1098557

Coskun Dilcan, Ç. (2023) Use of Artificial Intelligence Approach for The Modeling of Water-Energy-Climate Nexus. Dissertation. Hacettepe University. Ankara, Türkiye.

Cüceloğlu, G., Abbaspour, K., & Öztürk, İ. (2017). Assessing the water-resources potential of Istanbul by using a soil and water assessment tool (swat) hydrological model. Water, 9(10), 814. https://doi.org/10.3390/w9100814

Çakmak, B. and Avcı, S. (2017). Tarımda su tasarrufu ve sulama suyu fiyatlandırma yaklaşımları. Nevşehir Bilim Ve Teknoloji Dergisi, 6, 198-206. https://doi.org/10.17100/nevbiltek.332094

Çapar, G., & Yetiş, Ü. (2018). Sanayide Su Verimliliğinin Ülkemizdeki Durumu. Anahtar Dergisi, 19–24. Retrieved from http://suyonetimi.ankara.edu.tr/wp-content/uploads/sites/88/2018 /10/Anahtar-Dergisi-Sanayide-Su-Verimliliğinin-Ülkemizdeki-Durumu.pdf

Dash, S. (2024). Climate crisis and agricultural response: climate resilient crops for sustainability in food production systems. Journal of Experimental Agriculture International, 46(6), 440-458. https://doi.org/10.9734/jeai/2024/v46i62496

Demirbilek, B. and Benson, D. (2019). Between emulation and assemblage: analysing wfd policy transfer outcomes in Türkiye. Water, 11(2), 324. https://doi.org/10.3390/w11020324

Dilcan Coşkun, Ç., Çapar, G., Korkmaz, A., İritaş, Ö., Karaaslan, Y., & Selek, B. (2018). İçme Suyu Şebekelerinde Görülen Su Kayıplarının Dünyada ve Ülkemizdeki Durumu. Anahtar Dergisi, 354, 10–18.

DSİ, 2015. DSİ Activity Report 2015, Ankara.

DSI, 2023. 2023 Year Activity Report. https://cdniys.tarimorman.gov.tr/api/File/GetFile/425 / Sayfa/759/1107/DosyaGaleri/dsi_2023_yili_faaliyet_raporu.pdf#page=40

DSI, 2024a. 2022 Yılı Faaliyet Raporu. Ankara. Republic of Türkiye Ministry of Agriculture and Forestry, General Directorate of State Hydraulic Works (DSİ) https://cdniys.tarimorman.gov.tr/ api/File/GetFile/425/Sayfa/759/1107/DosyaGaleri/2021_yili_faaliyet_raporu.pdf

DSI, 2024b. Toprak Su Kaynakları. Republic of Türkiye Ministry of Agriculture and Forestry, General Directorate of State Hydraulic Works (DSİ) https://www.dsi.gov.tr/Sayfa/Detay/754

DSI, 2024c. DSİ 2020 Yılı Resmi Su Kaynakları İstatistikleri Republic of Türkiye Ministry of Agriculture and Forestry, General Directorate of State Hydraulic Works (DSI) https://www.dsi.gov.tr/Sayfa/Detay/1499

Eklund, L. and Thompson, D. (2017). Differences in resource management affects drought vulnerability across the borders between Iraq, Syria, and Türkiye. Ecology and Society, 22(4). https://doi.org/10.5751/es-09179-220409

ENSTİTUSU, 2024. Ankara University Water Management Institute. https://suyonetimi.ankara.edu.tr/en/preface/

Erdin, H.E., 2001, Şehir Planlamada Su ve Kanalizasyon Sistemleri Proje Eşiklerinin Değerlendirilmesi, Yüksek Lisans Tezi, Dokuz Eylül Üniversitesi Fen Bilimleri Enstitüsü, İzmir, 2001.

Falkenmark, M; Lundqvist; J.; Widstrand C. (1989). Macro-Scale Water Scarcity Requires Micro-Scale Approaches: Aspects of Vulnerability in Semi-Arid Development. Natural Resources Forum 13 (4): 258–267.

García-Rubio, M., Ruiz-Villaverde, A., & González-Gómez, F. (2015). Urban water tariffs in Spain: what needs to be done?. Water, 7(4), 1456-1479. https://doi.org/10.3390/w7041456

Green, T.R. (2016). Linking Climate Change and Groundwater. In: Jakeman, A.J., Barreteau, O., Hunt, R.J., Rinaudo, JD., Ross, A. (eds) Integrated Groundwater Management. Springer, Cham. https://doi.org/10.1007/978-3-319-23576-9_5

GoT (2018). 11th Development Plan, 2018 (On birinci Kalkınma Planı). https://www.sbb.gov.tr/wp-content/uploads/2022/07/On_Birinci_Kalkinma_Plani-2019-2023.pdf

Gürkan, H., Shelia, V., Bayraktar, N., Yildirim, Y., Yesilekin, N., Gündüz, A., ... & Hoogenboom, G. (2020). Estimating the potential impact of climate change on sunflower yield in the Konya province of Türkiye. The Journal of Agricultural Science, 158(10), 806-818. https://doi.org/10.1017/s0021859621000101

Güven, M. (2024). Hanehalkı su tüketimi ve tarife yapısı: Türkiye'de üç büyükşehir üzerine bir analizi. Sosyoekonomi, 32(59), 151-172. https://doi.org/10.17233/sosyoekonomi.2024.01.07

GSL, 2024. Su Yönetiminde Kayıp ve Kaçakların Önlenmesi İçin En İdeal Haberleşme Nasıl Sağlanır? https://gsl.com.tr/su-yonetiminde-kayip-ve-kacaklarin-onlenmesi

Habich-Sobiegalla, S. (2018). How do central control mechanisms impact local water governance in China? the case of Yunnan province. The China Quarterly, 234, 444-462. https://doi.org/10.1017/s0305741018000450

Hacısalihoğlu, S. and Karaer, F. (2018). Evaluation of water quality in eutrophic shallow lakes: case study on lake Uluabat, Türkiye. International Journal of Agriculture Environment and Food Sciences, 2(1), 18-28. https://doi.org/10.31015/jaefs.18004

Hagihara, K., Asahi, C., & Hagihara, Y. (2004). Marginal willingness to pay for public investment under urban environmental risk: the case of municipal water use. Environment and Planning C Government and Policy, 22(3), 349-362. https://doi.org/10.1068/c02105s

Harmancioglu, N., B., and Altınbilek, D., 2020. World Water Resources- Water Resources of Türkiye, Springer Nature. ISSN 2509-7393. https://doi.org/10.1007/978-3-030-11729-0

Hattum, T., Blauw, M., Jensen, M. B., & de Bruin, K. (2016). Towards Water Smart Cities: climate adaptation is a huge opportunity to improve the quality of life in cities (No. 2787). Wageningen University & Research.

Heidari, H., Arabi, M., Warziniack, T., & Sharvelle, S. (2021). Effects of urban development patterns on municipal water shortage. Frontiers in Water, 3. https://doi.org/10.3389/frwa.2021.694817

Hurlimann, A. and Wilson, E. (2018). Sustainable urban water management under a changing climate: the role of spatial planning. Water, 10(5), 546. https://doi.org/10.3390/w10050546

Hyde-Smith, L., Zhan, Z., Roelich, K., Mdee, A., & Evans, B. (2022). Climate change impacts on urban sanitation: a systematic review and failure mode analysis. Environmental Science & Technology, 56(9), 5306-5321. https://doi.org/10.1021/acs.est.1c07424

ICoI Istanbul Chamber of Industry, 2024. Clımate change and water management: Industrial sector report, Keyfindings. https://www.iso.org.tr/projeler/suraporu/

Johannessen, Å. and Wamsler, C. (2017). What does resilience mean for urban water services? Ecology and Society, 22(1). https://doi.org/10.5751/es-08870-220101

Kibaroğlu, A., Sağsen, İ., Kaplan, Ö., Sümer, V., 2006. "Türkiye'nin Su Kaynakları Politikasına Kapsamlı Bir Bakış: Avrupa Birliği Su Çerçeve Direktifi ve İspanya Örneği". TMMOB Su Politikaları Kongresi, 21-23 March 2006.

Kibaroğlu, A. (2022). Türkiye's water security policy: energy, agriculture, and transboundary issues. Insight Türkiye, 24 (Spring 2022), 69-88. https://doi.org/10.25253 /99.2022242.5

Kim, J. and Ryu, J. (2020). Decision-making of lid-bmps for adaptive water management at the boise river watershed in a changing global environment. Water, 12(9), 2436. https://doi.org/10.3390/w12092436

Koç, C., Bakış, R., & Bayazıt, Y. (2017). A study on assessing the domestic water resources, demands and its quality in holiday region of Bodrum Peninsula, Türkiye. Tourism Management, 62, 10-19.

Kohlitz, J., Chong, J., & Willetts, J. (2017). Climate change vulnerability and resilience of water, sanitation, and hygiene services: a theoretical perspective. Journal of Water Sanitation and Hygiene for Development, 7(2), 181-195. https://doi.org/10.2166/washdev.2017.134

Kourgialas, N. (2021). Editorial: could advances in geoinformatics, irrigation management and climate adaptive agronomic practices ensure the sustainability of water supply in agriculture? Water Science & Technology Water Supply, 21(6), v-vii. https://doi.org/10.2166/ws.2021.244

Kumanlıoğlu, A. (2019). Characterizing meteorological and hydrological droughts: a case study of the gediz river basin, Türkiye. Meteorological Applications, 27(1). https://doi.org/10.1002/met.1857

Küçükçelebi, C., 2014. "Avrupa Birliği Uyum Sürecinde Türkiye'nin Su Politikası, Su Hukuku ve Su Kaynakları Yönetiminde Yeniden Yapılanmalar". Master Thesis, İstanbul Technical University, Gradu76. ate School Of Natural And Applied Sciences, Istanbul.

Lobina, E. (2005). Problems with private water concessions: a review of experiences and analysis of dynamics. International Journal of Water Resources Development, 21(1), 55-87. https://doi.org/10.1080/0790062042000313304

Ma, X., Wu, D., & Zhang, S. (2018). Multiple goals dilemma of residential water pricing policy reform: increasing block tariffs or a uniform tariff with rebate? Sustainability, 10(10), 3526. https://doi.org/10.3390/su10103526

Macchiaroli, M., Dolores, L., & Mare, G. (2023). Multicriteria decision making and water infrastructure: an application of the analytic hierarchy process for a sustainable ranking of investments. Applied Sciences, 13(14), 8284. https://doi.org/10.3390/app13148284

Mbogo, M. (2023). Project management capabilities and sustainability of water projects funded by embu county government, kenya. strategicjournals.com, 10(4). https://doi.org/10.61426/sjbcm.v10i4.2786

Mehran, A., AghaKouchak, A., Nakhjiri, N., Stewardson, M., Peel, M., Phillips, T., ... & Ravalico, J. (2017). Compounding impacts of human-induced water stress and climate change on water availability. Scientific Reports, 7(1). https://doi.org/10.1038/s41598-017-06765-0

Mekonnen, M. M., & Hoekstra, A. Y. (2016). Four billion people facing severe water scarcity. Science advances, 2(2), e1500323. https://www.science.org/doi/pdf/10.1126/ sciadv.1500323?source=content_type%3Areact%7Cfirst_level_url%3Aarticle%7Csection%3 Ama in _content%7Cbutton%3Abody_link

MoAF (2016). Impact of Climate Change on Water Resources Project, Executive Summary. https://www.tarimorman.gov.tr/SYGM/Belgeler/iklim%20de%C4%9Fi%C5%9Fikli%C4%9Finin%20su%20kaynaklar%C4%B1na%20etkisi/Iklim_Nihai%20Rapor_YoneticiOzeti.pdf

MoAF (2021a). Climate Change and Agriculture Assessment Report. https://www.tarimorman.gov.tr/TRGM/Belgeler/IKLIM%20DEGISIKLIGI%20VE%20TARIM%20DEGERLENDIRME%20RAPORU.pdf

MoAF (2021b). Water Council. https://susurasi.tarimorman.gov.tr/

MoAF (2022). 2023-2027 Agricultural Drought Strategy and Action Plan. https://www.tarimorman.gov.tr/TRGM/Belgeler/0TARIMSAL%20%C3%87EVRE%20VE%20DO%C4%9EAL%20KAYNAKLARI%20KORUMA%20DA%C4%B0RE%20BA%C5%9EKANLI%C4%9EI/Yay%C4%B1nlar%C4%B1m%C4%B1z/Tar%C4%B1msal%20Kurakl%C4%B1kla%20Mu%CC%88cadele.pdf

MoAF (2023a). Water Efficiency Campaign. Water Efficiency Strategy Document and Action Plan in the Framework of Adaptation to The Changing Climate (2023-2033). https://suverimliligi.gov.tr/wp-content/uploads/2023/10/su-vermliligi-eylem-plani-en.pdf

MoAF (2023b). Minister Kirisci: Average loss and leakage in drinking water is 33 percent. We must bring this down quickly. https://www.aa.com.tr/tr/gundem/bakan-kirisci-icme-suyunda-kayip-kacak-ortalamasi-yuzde-33-bunu-hizla-asagi-cekmeliyiz/2795024

MoAF (2023c). The Climate Change Adaptation in Water Resources Project. https://www.tarimorman.gov.tr/SYGM/Belgeler/Su%20Kaynaklar%C4%B1%20%C4%B0klim%20Proje/Su%20Kaynaklar%C4%B1nda%20%C4%B0klim%20De%C4%9Fi%C5%9Fikli%C4%9Fine%20Uyum%20Projesi%20Tan%C4%B1t%C4%B1m%20Bro%C5%9F%C3%BCr%C3%BC.pdf

MoAF (2024). Water Usage Service Fee Tariffs. https://cdniys.tarimorman.gov.tr/api/File/GetGaleriFile/425/DosyaGaleri/603/sukulhizbedlitarifesb2024.pdf

MoAF (2024b). Water Waste Survey Evaluation. https://www.tarimorman.gov.tr/Haber /5098 /Tarim-Ve-Orman-Bakanligindan-Türkiyenin-Su-Tuketim-Aliskanliklarini-Ortaya-Koyan-Arastirma

Mirhanoğlu, A., Loopmans, M., & Özerol, G. (2021). Social head-enders: access and authority in irrigation governance. Society & Natural Resources, 35(2), 185-203. https://doi.org/10.1080/089 41920.2021.2009944

MoEU (2012). National Climate Change Action Plan 2011-2023, Ministry of Environment and Urbanization, Ankara. https://webdosya.csb.gov.tr/db/iklim/editordosya/uyum_stratejisi_eylem _plani _TR.pdf

MFWA GDWM (Former), 2017. Lakes and Wetlands Action Plan (2017-2023) (in Turkish).

Mizyed, N. (2008). Impacts of climate change on water resources availability and agricultural water demand in the west bank. Water Resources Management, 23(10), 2015-2029. https://doi.org/10.1007/s11269-008-9367-0

Muhammetoğlu, H. & Muhammetoğlu, A., 2017. Orman ve Su İşleri Bakanlığı Su Yönetimi Genel Müdürlüğü, İçme Suyu Temin ve Dağıtım Sistemlerindeki Su Kayıplarının Kontrolü El Kitabı.

Murungu, R., Bankole-Bolawole, O., Odhiambo, C., Mwangi, C., & Aboma, G. (2022). Inclusion of water, sanitation and hygiene in ethiopia`s nationally determined contributions 2020 update process- a policy brief. Sustainable Development Research, 4(1), p.32. https://doi.org/10.30560/sdr.v4n1p32

Nguyen, P., Trieu, H., Anh, M., & Nguyen, A. (2021). Evaluating critical success factors in public – private partnership water supply infrastructure projects. SHS Web of Conferences, 129, 09012. https://doi.org/10.1051/shsconf/202112909012

Nhemachena, C., Matchaya, G., Nhlengethwa, S., & Nhemachena, C. (2018). Exploring ways to increase public investments in agricultural water management and irrigation for improved agricultural productivity in Southern Africa. Water Sa, 44(3 July). https://doi.org/10.4314/wsa.v44i3.15

Nhlengethwa, S., Matchaya, G., Greffiths, I., & Fakudze, B. (2020). Analysis of the determinants of public capital investments on agricultural water infrastructure in Eswatini. Business Strategy & Development, 4(1), 49-58. https://doi.org/10.1002/bsd2.156

Nwokediegwu, Z. (2024). Urban water management: a review of sustainable practices in the USA. Engineering Science & Technology Journal, 5(2), 517-530. https://doi.org/10.51594/estj. v5i2.829

NuWater (2024). Optimizing Water Efficiency in Industrial Operations: A Sustainable Approach https://nuwater.com/optimizing-water-efficiency-in-industrial-operations/

OECD, 2024. OECD Water Policies Country Note: Türkiye. Agrıculture And Water Polıcıes: Maın Characterıstıcs And Evolution From 2009 To 2019. (Access Date: 04.03.2024) https://www.oecd.org/agriculture/topics/water-and-agriculture/documents/oecd-water-policies-country-note-Türkiye.pdf

Opere, M. (2023). Analyzing the interplay of environmental virology, public health, and sanitation: a comprehensive review from a kenyan perspective. Frontiers in Cellular and Infection Microbiology, 13. https://doi.org/10.3389/fcimb.2023.1256822

Ozgun, H., Cicekalan, B., & Ozturk, I. (2018). A comparative evaluation of tariff affordability ratio for water and wastewater management sector in Türkiye. Sakarya University Journal of Science, 22(2), 806-815. https://doi.org/10.16984/saufenbilder.329934

Özdemir, A., Karakaya, N., Altuntaş, A., & KOÇ, A. (2022). Land use and climate change impacts on flow rate and non-point pollution sources in drinking water basins: namazgah dam basin. https://doi.org/10.22541/au.164330475.59684688/v1

Piazzi, G., Thirel, G., Perrin, C., & Delaigue, O. (2021). Sequential data assimilation for streamflow forecasting: assessing the sensitivity to uncertainties and updated variables of a conceptual hydrological model at basin scale. Water Resources Research, 57(4). https://doi.org/10.1029/2020wr028390

Pilevneli, T., Capar, G.,. Cerda, C. S. (2023). Investigation of climate change impacts on agricultural production in Türkiye using volumetric water footprint approach, Sustainable Production and Consumption Vol 35 (2023), 605-623.

Qu, S., Liang, S., Konar, M., Zhu, Z., Chiu, A., Jia, X., ... & Xu, M. (2017). Virtual water scarcity risk to the global trade system. Environmental Science & Technology, 52(2), 673-683. https://doi.org/10.1021/acs.est.7b04309

Radonic, L. and Zúñiga-Terán, A. (2023). When governing urban waters differently: five tenets for socio-environmental justice in urban climate adaptation interventions. Sustainability, 15(2), 1598. https://doi.org/10.3390/su15021598

Ray, S., Pati, A., Jhankar, A., Sahoo, A., Paul, J., Sahoo, B., ... & Majhi, P. (2023). Advancements in modeling protocols for assessing climate change impacts on water resources: a review. International Journal of Environment and Climate Change, 13(4), 190-197. https://doi.org/10.9734/ijecc/2023/v13i41726

Rezaei, E., Ghazaryan, G., & Yamaç, S. (2023). Crop production in Türkiye: trends and driving variables. Environmental Research Communications, 5(3), 031001. https://doi.org/10.1088/2515-7620/acbd1e

Roeger, A., Tavares, A.F. (2021). Water Safety Plans and Climate Change Mitigation. In: Leal Filho, W., Marisa Azul, A., Brandli, L., Lange Salvia, A., Wall, T. (eds) Partnerships for the Goals. Encyclopedia of the UN Sustainable Development Goals. Springer, Cham. https://doi.org/10.1007/978-3-319-95963-4_91

Rost, L. and Koissy-Kpein, S. (2018). Infrastructure and equipment for unpaid care work: household survey findings from the Philippines, Uganda and Zimbabwe – 2017 household care survey report. https://doi.org/10.21201/2017.1671

Ruiters, C. and Matji, M. (2016). Public–private partnership conceptual framework and models for the funding and financing of water services infrastructure in municipalities from selected provinces in South Africa. Water Sa, 42(2), 291. https://doi.org/10.4314/wsa.v42i2.13

Sakal, H. (2020). Türkiye's energy trade relations with Europe: the role of institutions and energy market. Energy & Environment, 32(7), 1243-1274. https://doi.org/10.1177/ 0958305x20977298

SBD (2024). Presidency of the Republic of Türkiye's Strategy and Budget Directorate. The 2023 Investment Program. https://www.sbb.gov.tr/2023-yili-yatirim-programi-yayimlandi/

Serin, Ş. and Demir, M. (2023). Does public debt and investments create crowding-out effect in Türkiye? evidence from ARDL approach. Sosyoekonomi, 31(55), 151-172. https://doi.org/10.17233 / sosyoekonomi.2023.01.08

Sivakumar, M.V., Motha, R.P., Das, H.P. (eds), 2005. Natural Disasters and Extreme Events in Agriculture. Springer, Berlin, Heidelberg. ISBN-10 3-540-22490-4.

Sputnik Türkiye, 2024. The metropolitan municipality with the most affordable water usage in Türkiye has been determined: 10 times cheaper than Izmir. https://anlatilaninotesi.com.tr/ 20240204 /Türkiyede-en-uygun-fiyata-su-kullanan-sehir-belli-oldu-izmirden-10-kat-daha-ucuz-1080381483.html

Su Enstitüsü, 2024. Süleyman Demirel University, Water Institute. https://sue.sdu.edu.tr/tr/tanitim/hakkinda-2104s.html

SUEN, 2024. Turkish Water Institute. https://www.suen.gov.tr/Suen/en/page.asp x?pg=about_us

Suratin, A., Triakuntini, E., & Herdiansyah, H. (2019). Effects of the implementation of a progressive tariffs policy on water management in dki jakarta, indonesia. Environmental & Socio-Economic Studies, 7(4), 36-44. https://doi.org/10.2478/environ-2019-0022

World Bank, 2016. Republic of Türkiye Natural Capital Accounting Valuing Water Resources in Türkiye A Methodological Overview and Case Study https://documents1.worldbank.org/ curated/ en/600681476343083047/pdf/AUS10650-REVISED-PUBLIC-Türkiye-NCA-Water-Valuation-Report-FINAL-CLEAN.pdf

TAGEM, 2021. Tarımsal Sulama Sektör Politika Belgesi (2021-2025). Tarım Ve Orman Bakanlığı. Tarımsal Araştırmalar Ve Politikalar Genel Müdürlüğü. https://www.tarimorman.gov.tr/ TAGEM/Belgeler/yayin/Tar%C4%B1msal%20Sulama%20SPB_2021-2025.pdf

TEMA-WWF Türkiye. (Mart, 2015). İklim Değişikliğinin Yerel Etkileri Raporu. ISBN: 978-975-7169-77-2. https://cdn-tema.mncdn.com/Uploads/Cms/iklim-degisikliginin-yerel-etkiler-rap oru.pdf

Terry, J., Casello, J., & Bachmann, C. (2017). Origin revenue sources for infrastructure funding. Transportation Research Record Journal of the Transportation Research Board, 2606(1), 96-105. https://doi.org/10.3141/2606-13

Tosun, J. and Leopold, L. (2019). Aligning climate governance with urban water management: insights from transnational city networks. Water, 11(4), 701. https://doi.org/10.3390/w11040701

Tuğaç, Ç., 2022. Kentler, iklim değişikliğiyle mücadele ve uyum. Temiz Enerji Haber Portalı. https://temizenerji.org/2022/03/10/kentler-iklim-degisikligiyle-mucadele-ve-uyum/

TUIK, 2023. Turkish Statistical Institute. Water and Wastewater Statistics, 2022. https://data.tuik.gov.tr/Bulten/Index?p=49607&dil=2

TUIK (2024). Bitkisel Üretim İstatikleri. https://data.tuik.gov.tr/Bulten/Index?p=Bitkisel-Uretim-Istatistikleri-2023-49535

Turhan, E., Mazlum, S., Şahin, Ü., Şorman, A., & Gündoğan, A. (2016). Beyond special circumstances: climate change policy in Türkiye 1992–2015. Wiley Interdisciplinary Reviews Climate Change, 7(3), 448-460. https://doi.org/10.1002/wcc.390

TSMS (2021). Meteorological Disaster Assessment of Türkiye (2010-2021). https://mgm.gov.tr/FILES/genel/raporlar/meteorolojikafetler2010-2021.pdf

UN (2023 a). United Nations Sustainable Development Goals. Goal 2: Zero Hunger https://www.un.org/sustainabledevelopment/hunger/

UN (2023 b). SDG Extended Report 2022. https://unstats.un.org/sdgs/report/2022/exten ded report/

USIAD, 2011. National Industry and Business Association (Ulusal Sanayici ve İşadamları Derneği in Turkish). Türkiye'de Su Yönetimi Nasıl Olmalı?

Valta, K., Μουστάκας, K., Sotiropoulos, A., Malamis, D., & Haralambous, K. (2015). Adaptation measures for the food and beverage industry to the impact of climate change on water availability. Desalination and Water Treatment, 57(5), 2336-2343. https://doi.org/10.1080/ 19443994.2015.1049407

Wang, N. (2024). A study on the driving mechanisms of water supply and demand perception in the digital age. jes, 20(2), 1911-1923. https://doi.org/10.52783/jes.1638

Wang, K., Sun, S., Li, Y., Hu, X., Qi, X., Wang, J., ... & Gao, F. (2022). Response of regional agricultural water use to the change of climate and plantation structure in the typical agricultural region of china. Journal of Water and Climate Change, 13(3), 1370-1388. https://doi.org/10.2166/wcc.2022.416

Wang, M., Zhang, D., Su, J., Trzcinski, A., Dong, J., & Tan, S. (2017). Future scenarios modeling of urban stormwater management response to impacts of climate change and urbanization. Clean - Soil Air Water, 45(10). https://doi.org/10.1002/clen.201700111

WHO & UNICEF (2000). Global Water Supply and Sanitation Assessment 2000 Report. Iseman Creative, Washington, DC.

WWF (2014). The Water Footprint Report of Türkiye: The Relationship Between Water, Production, and International Trade (in Turkish) https://www.wwf.org.tr/?2720/trkiyeninsuayaki ziraporu

Yoder, J., Adam, J., Brady, M., Cook, J., Katz, S., Johnston, S., ... & Yang, Q. (2017). Benefit-cost analysis of integrated water resource management: accounting for interdependence in the Yakima basin integrated plan. Jawra Journal of the American Water Resources Association, 53(2), 456-477. https://doi.org/10.1111/1752-1688.12507

Xia, J., Wang, Z., Wang, G., & Tan, G. (2004). The renewability of water resources and its quantification in the yellow river basin, china. Hydrological Processes, 18(12), 2327-2336. https://doi.org/10.1002/hyp.5532

Yağbasan, Ö. (2016). Impacts of climate change on groundwater recharge in küçük menderes river basin in western Türkiye. Geodinamica Acta, 28(3), 209-222. https://doi.org/10.1080/ 09853111.2015.1121802

Yaykiran, S., Cüceloğlu, G., & Ekdal, A. (2019). Estimation of water budget components of the sakarya river basin by using the weap-pgm model. Water, 11(2), 271. https://doi.org/10.3390/w11020271

Yazdi, N., Mousavi, S., Zarei, A., & Shirvanian, A. (2022). Investigating the effects of climate change, drought, and agricultural sector policies on the trend of the water poverty index in Iran. Journal of Water Supply Research and Technology—aqua, 71(3), 433-449. https://doi.org/10.2166/aqua.2022.112

Yetik, A. (2023). Trends and variability in precipitation across Türkiye: a multimethod statistical analysis. Theoretical and Applied Climatology, 155(1), 473-488. https://doi.org/10.1007/s00704-023-04645-4

Yildiz, D., Yildiz, D., & Güneş, M. (2019). Yukarı fırat havzasının uzun dönem akım eğilimlerinin analizi. European Journal of Science and Technology, 118-131. https://doi.org/10.31590/ejosat.500548

Yu, Y., Xie, Y., Ji, L., Zhang, J., Cai, Y., & Yang, Z. (2021). Water management for industrial development, energy conservation, and subjective attitudes: a comprehensive risk-oriented model to explore the tolerance of unbalanced allocation problem. Journal of Water and Climate Change, 13(1), 139-157. https://doi.org/10.2166/wcc.2021.377

Yüksel, I. (2015). Water management for sustainable and clean energy in Türkiye. Energy Reports, 1, 129-133. https://doi.org/10.1016/j.egyr.2015.05.001

Zhang, X. (2015). Conjunctive surface water and groundwater management under climate change. Frontiers in Environmental Science, 3. https://doi.org/10.3389/fenvs.2015.00059

Zhang, M. and Batjargal, T. (2022). Review on new spending of united states bipartisan infrastructure bill. Journal of Infrastructure Policy and Development, 6(2), 1507. https://doi.org/10.24294/jipd.v6i2.1507


UZBEKISTAN

LIST OF ABBREVIATIONS

ADB	Asian Development Bank
AIS	Administration of the Irrigation Systems
BAIS	Basin Administration of Irrigation Systems
CA	Central Asia
CMC	Coordination Meteorological Center
DID	District Irrigation Departments
FAO	The Food and Agriculture Organization of the United Nations
GDP	Gross Domestic Product
GoU	Government of the Republic of Uzbekistan
GW	Groundwater
ICWC	The Interstate Commission for Water Coordination
IFAS	International Fund for Saving the Aral Sea
IPCC	The Intergovernmental Panel on Climate Change
IWRM	Integrated Water Resources Management
MWR	Ministry of Water Resources
PPP	Public- Private Partnership
BWO	River Basin Authorities
SIC ICWC	Scientific-Information Center of the Interstate Coordination Water Commission
SRTM	The Shuttle Radar Topography Mission
UN	United Nations
SDG	Sustainable Development Goals
USD	United States of America Dollar
Uzhydromet	Agency of Hydrometeorological Service of the Republic of Uzbekistan
UZS	Uzbekistan Soum
UzStat	Statistics Agency of Uzbekistan
WCA	Water Consumer Associations
WMO	Water-Management Organizations
WB	World Bank
WRI	World Resources Institute,
WSS	Water Supply and Sanitation

EXECUTIVE SUMMARY

Uzbekistan, a landlocked country in Central Asia, is located mainly between two major rivers, the Syr Darya to the northeast and the Amu Darya to the southwest. Uzbekistan borders Kazakhstan to the northwest and north, Kyrgyzstan and Tajikistan to the east and southeast, Afghanistan to the south, and Turkmenistan to the southwest.

As other countries of the region, Uzbekistan also faces significant challenges in water management, exacerbated by a combination of climatic, physical, economic, and institutional factors. The country is heavily dependent on transboundary rivers, particularly the Amu Darya and Syr Darya, which originate in neighboring countries. Climate change is expected to exacerbate water shortages, leading to an increased frequency of droughts, and increased requirements of irrigation water. Outdated and heavily used infrastructure with rapid population growth and insufficient investment in the sector, until recently, contributes to water scarcity. Legacy irrigation infrastructure and entrance of Afghanistan to the water withdrawal, decreases water availability and reliance on the traditional irrigation will only exacerbate water availability crisis. The agricultural sector, which consumes most water resources, suffers from low productivity, partially due to water use inefficiencies. Industry and public water consumption having higher priorities doesn’t seem to suffer yet. Although providing potable water from good quality sources in the rural areas and growing pressure of the urban development on old city infrastructure must be addressed.

The program “Development of the Water Sector for 2020-2030” addresses agriculture modernization and increasing of the water use efficiency in forcing water saving technologies and application of the drip-irrigation as well as water control and further pricing.

The institutional framework governing water management in Uzbekistan is fragmented and complicated. There is still a lack of coordination between different responsible public agencies, leading to overlapping and inefficiency in water management. Moreover, the existing water laws and regulations are not fully aligned with the principles of integrated water resources management (IWRM). This misalignment hinders the effective implementation of policies aimed at improving water efficiency and sustainability.

Uzbekistan has identified several strategic priorities in future development of the water sector. These include modernizing irrigation infrastructure such as lining of the canal, modernization of water pump station, enhancing water use efficiency such as laser leveling of the fields, and promoting the adoption of water-saving technologies with wide credit subsidies for drip and sprinkler irrigation in recent years. The government also aims to strengthen the institutional framework for water management by improving coordination between agencies and aligning water laws with IWRM principles. Water code law that is now under consideration and development will have to address these questions additionally, focus on increasing investment in the water sector, both from public and private sources, to support sustainable water management practices.

Environmental sustainability is a critical consideration in Uzbekistan's water management strategy. Especially with the Aral Sea crisis and desertification issues especially prevalent in the west side of the country. The country is committed to mitigating the environmental impact of water use, particularly in the agricultural sector. This includes efforts to reduce water pollution, improve soil quality, restore degraded ecosystems and create green ecosystems. Socially, the government is focused on ensuring equitable access to water resources, particularly for rural communities that are most affected by water shortages.

Thus, the current Report covers all aspects of the water management in Uzbekistan and structured as below.

Chapter 1 covers current water availability in the Uzbekistan and water withdrawal by the Aral Sea Basin country parts. It also addresses water formation and distribution in the basin, as Uzbekistan water resources are transboundary in nature it requires overview of the whole basin. It also addresses water consumers with 90% agriculture taking the largest share from industry, fishery and urban needs. It also covers areas of the current situation in water sanitation and potable water availability in the region.

Chapter 2 describes institutional framework and legal structure of water use and regulation. The chapter addresses the main laws, decrees and regulations of water use and tariffs for surface and groundwater resources. Structure of the national governance and authorities involved in the strategic planning and implementation, responsible for overseeing water distribution, usage, and conservation within their respective jurisdictions is also addressed.

Chapter 3 analyses the impact of climate change on water resources management and availability in future. Increased temperatures and their impact to the future water requirements. Observation suggests Uzbekistan is experiencing ongoing climatic changes within Uzbekistan, driven by both anthropogenic factors and natural variability. It also may face chronic meteorological drought by the 2090s, with projections showing potential shifts in precipitation and increasing water stress.

Chapter 4 covers water tariffs and investment into the water infrastructure. Ongoing international partnerships to address inefficiencies and ensure long-term sustainability; including significant investments in lining irrigation canals, expanding water-saving technologies, and digitizing canal management systems. Water tariffs and subsidies that encourages water saving for final customers.

Chapter 5 addresses future water resources management, stopping on the impacts of the unresolved issue of the new canal development in the Afghanistan and climate change impact on water availability in the future. Increased demand by other sectors other than agriculture will require significant investments to address it. Adaptation measures require addressing water sharing, modern infrastructure investments, water-saving technologies and alternative energy sources to ensure sustainable water resources and resilience to future challenges.

Chapter 6 examines transboundary water cooperation among Central Asian counties in particular and Turkic states in general. It highlights recommendations on how to mitigate against climate change across the region.

INTRODUCTION

Uzbekistan, with an area of 448,978 km² is a doubly landlocked country located in the Irano-Turanian lowlands of Central Asia. The country has various physical and geographical conditions, with arid and semi-arid plains covering 78.8% of the central and northwestern regions and mountains comprising 21.2% of the southern, southeastern, and eastern areas (Sadykov, 1975).

The topography of Uzbekistan can be divided into 3 major parts (Figure 1): western, central and eastern parts (Lehner et al., 2008). In the western part of the country lies an expansive flat plain comprised of the Turanian lowlands and depressions of the former Aral Sea. The former bed of the Aral Sea now forms Aralkum desert, a direct consequence of the gradual drying up of the Aral Sea (Orlovsky et al., 2013; Nishonov et al., 2023).

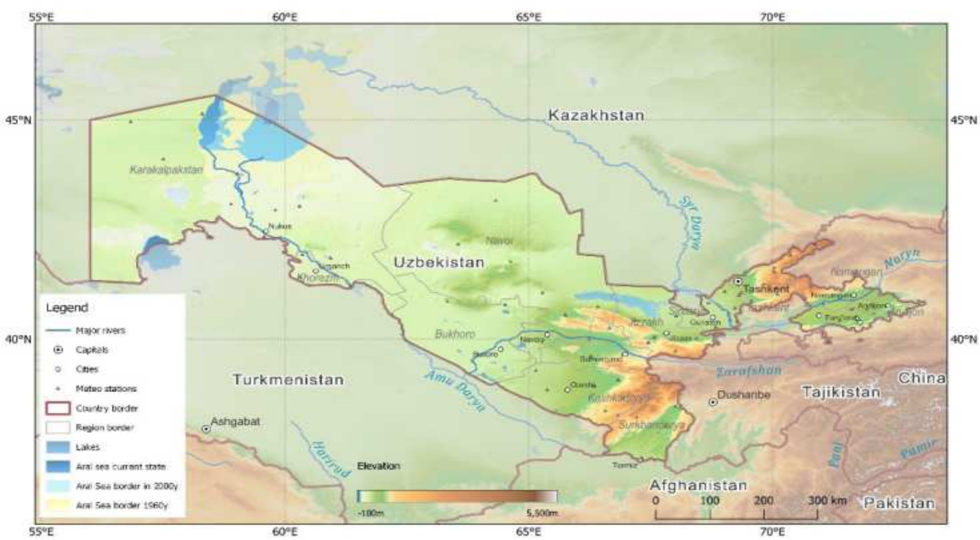


Figure 1. Geographical map of Uzbekistan

The central part of the country is predominantly flat, with the Kyzylkum desert stretching from the northern border with Kazakhstan to the southern border with Turkmenistan, connecting to the Karakum desert. Elevations across this area typically do not exceed 100 to 250 meters above sea level, creating vast arid plains that dominate the landscape. The eastern part of Uzbekistan combines mix of high mountains of the Tien Shan and Gissar Ranges with irrigated river valleys.

The climate in Uzbekistan is sharply continental and influenced by its central location within the Eurasian continent and topography. As the western and northern territories are mostly flat, they are exposed to cold air masses, resulting in hot summers and cold winters. The southern part is well protected by mountain ranges, including the Himalayas, Hindu Kush, Pamir, and Tien Shan, which block moisture from the Indian Ocean, the closest significant source of humidity. This geographic setup divides the landscape into western arid plains and eastern mountainous areas, with fertile, irrigated valleys along the rivers (Sadykov, 1975).

The arid and semi-arid landscapes of Uzbekistan receive limited rainfall, which heavily influences its climate, water resources, agriculture, and ecosystems. Annual precipitation averages from lower than 100 to 200 mm in the plains and up to 600 to 900 mm on the mountain slopes, occurring mainly in winter and spring (Kholmatjanov et al., 2020). The average rainfall index in Uzbekistan is estimated within 200 mm per year. This limited natural moisture significantly impacts the country's ecosystems and necessitates extensive water management strategies.

The plains experience long, hot summers and cold winters, while the mountainous regions exhibit temperature variations influenced by elevation, relief, and slope direction.

The seasonal distribution of precipitation in spring and winter, with minimal rainfall during the hot summer months, directly corresponds with the development and decline of vegetation in the deserts and plains. However, the subsequent intense summer heat quickly evaporates the limited moisture. Uzbekistan's arid and semi-arid characteristics are a direct result of the limited and uneven distribution of precipitation throughout the year (Zomer et. al, 2022) (Figure 2).

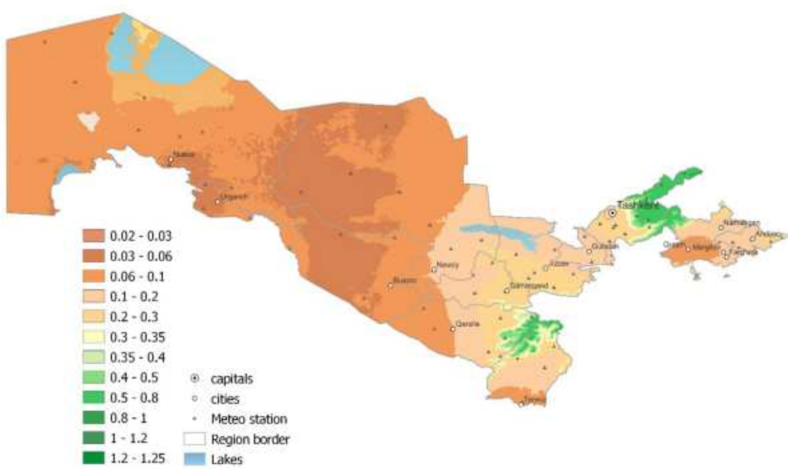


Figure 2. Aridity index of Uzbekistan

< 0.03 Hyper arid; 0.03 – 0.2 Arid; 0.2 - 0.5 Semi-arid; 0.5 – 0.65 Dry sub-humid; > 0.65 Humid

The river valleys form the primary centers of human habitation and agriculture in this arid landscape. These valleys are irrigated by the waters of the main rivers of Uzbekistan;

the Amu Darya, Syr Darya, and Zeravshan, Kashkadarya, Chirchik, Ahangaran rivers. These serve as the main living areas for the country's population (Figure 3 and Figure 4).

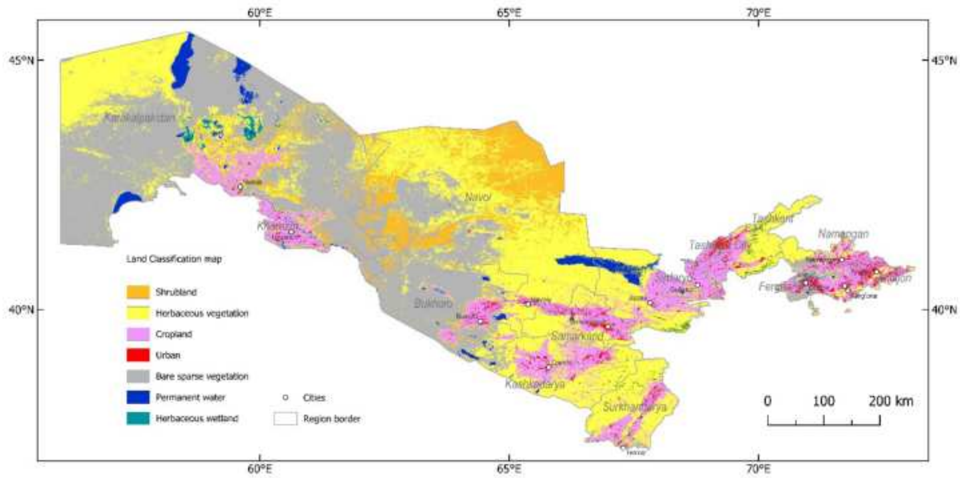


Figure 3. Land use classification of the Uzbekistan

Source: Buchhorn et al. 2020

The river valleys are not only the cultural and agricultural heartlands of Uzbekistan but also the epicenters of historical livelihood, with irrigation areas dating back over 2,000 years. The network of artificial canals and ditches, together with drainage systems, testifies to centuries of water redistribution, enabling diverse crops to flourish and supporting the livelihoods of the people.

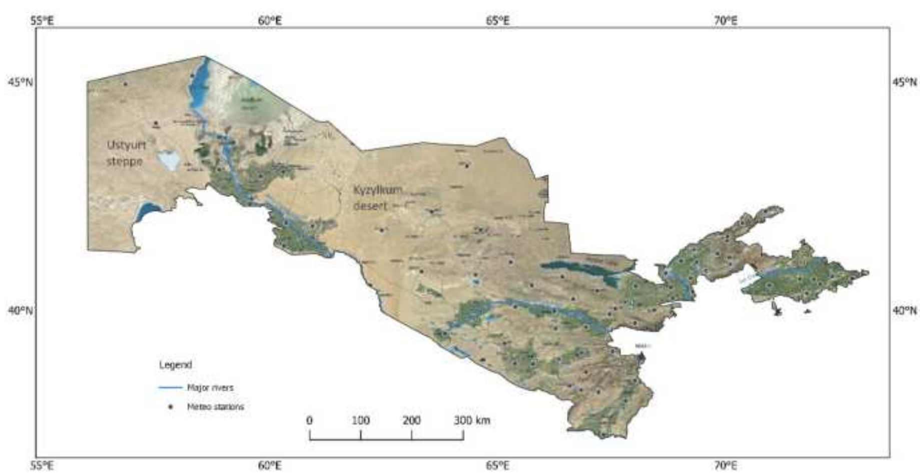


Figure 4. Overview of the Uzbekistan natural land cover

Uzbekistan has the most population in Central Asia, with over 37.03 million people (Uzstat, 2024). Half of the population lives in urban settlements, another half in rural. The rural population is mostly engaged in agriculture. Agriculture is the main water consumer in Uzbekistan and requires significant amounts for crop production due to limited precipitation.

CHAPTER 1. WATER AVAILABILITY, ABSTRACTION, AND DELIVERY

1.1. Available water resources

In Uzbekistan water supply is formed naturally in surface and groundwaters as well as anthropogenic origin from return flows from irrigated lands. Water resources here are transboundary in nature and should be considered as part of the Aral Sea Basin from which they share their main features (Figure 5). Only Kashkadarya and Ahangaran rivers from major ones can be fully formed within administrative borders of Uzbekistan. Rivers enter and outflow to and from the territory of Uzbekistan several times, thus, calculations of the total inflow and usage of the water should be considered within the region and the basin, instead of general overall inflow. Such calculations will always have to take into not only overall water flow through the territory of the country but account for water sharing agreements and real water usage within the territory of Uzbekistan.

Figure. 5. Aral Sea Basin and Transboundary River share inputs
Source: cawater-info.net

From a hydrological point of view one can distinguish three main zones of surface runoff: (a) the zone of flow formation (upper watersheds in the mountain areas in the south-east part – including Afghanistan, Kyrgyzstan and Tajikistan), (b) the zone of flow transit and its dissipation (the central part – mainly Kazakhstan, Turkmenistan and Uzbekistan), and (c) delta zones (the north-west part including Kazakhstan, Turkmenistan and Uzbekistan). The management of available water, often reliant on transboundary rivers, is crucial for mitigating the challenges posed by the arid climate, ensuring sustainable agriculture, and supporting the diverse ecosystems. As it was calculated the total available surface water resources in the basin are estimated at 116.5 x 10^9 m^3 per year (Table 1), from which only 10% of total is generated in the territory of Uzbekistan (Khamraev et al., 2020). Additionally, there is 31.17 x 10^9 m^3 groundwater reserves, of which 14.7 10^3 m^3 is in the Amu Darya River basin and 16.4 x 10^9 m^3 in the Syr Darya Basin.

Table 1. Total annual river flow formation in the Aral Sea Basin

Country	10^9 m^3			%
	Syr Darya,	Amu Darya	Area Sea basin	Aral Sea Basin,
Kazakhstan	2.426	–	2.426	2.1
Kyrgyz Republic	27.605	1.604	29.209	25.1
Tajikistan	1.005	49.898	50.585	43.4
Turkmenistan	–	1.549	1.549	1.2
Uzbekistan	6.167	4.736	11.223	9.6
Afghanistan & Ian	–	21.593	21.593	18.6
Total of Aral Sea Basin	37.203	79.380	116.585	100.0

The Amu Darya stands as the largest river in the region by water volume, with a length of 2,540 km and a catchment area spanning 309,000 km². Its source lies in Afghanistan at the Vakhjir Pass glacier. It takes the name Panj before joined by the Vakhsh from Kyrgyzstan and Tajikistan, acting as the boundary between Afghanistan, Tajikistan, and Uzbekistan. Further downstream, it forms international borders between Turkmenistan and Uzbekistan on its way to the Aral Sea. Amu Darya is heavily regulated, with 4 main locations that withdraw water to outside of the Aral Sea. These include Karakum Canal, which supplies water to Turkmenistan; the Kashkadarya Pump Cascade that provides water to the Kashkadarya region, Amu-Bukhara Canal supplying water to Bukhara region, Tuyamuyun Reservoir and Vier near Nukus that distributes water in Khorezm and Karakalpakistan regions. Additionally, there is the new Qosh-tepa Canal development in Afghanistan that was started in 2022 and is expected to withdraw water for irrigation needs from 2025. All above listed canals withdraw water from the Aral Sea and further stores it in the terminal lakes.

The Syr Darya, stretching 3,019 km, is the longest river in Central Asia, with a catchment area of 219,000 km². It originates in the Tian Shan Mountains of the Kyrgyz Republic, named the Naryn until it merges with the Kara Darya. Crossing international boundaries midstream, it flows through Kyrgyzstan and Uzbekistan, reaches Tajikistan, briefly returns to Uzbekistan, and eventually enters Kazakhstan (Murray-Rust et al., 2003). Generally, it is considered that only Aydar-Arnasai Lake system withdraw water from the Syr Darya River through a number of irrigation canals and drainage water collectors in addition to the timely releases of water from the Chardara water reservoir on the border of Uzbekistan and Kazakhstan, particularly in winter periods.

1.2. Water balance

Although the Amu Darya and the Syr Darya are the main sources of surface water to the Aral Sea Basin and Uzbekistan, there are also several smaller transboundary rivers such as Zeravshan and Kashkadarya in the Amu Darya Basin, Chirchik and Ahangaran in the Syr Darya Basin. However, presently, the water resources of the Zeravshan and Kashkadarya rivers are totally diverted for irrigation and only in very wet years some of the flow reaches the desert lakes or drainage collectors. Nowadays, annual average water consumption is estimated at around 51 x 10^6 m^3 out of which 40 x 10^6 m^3 is inflow from the neighboring countries and 11 x 10^6 m^3 is natural flow of Uzbekistan (MWR, 2023). Water consumption has been gradually decreasing over the last 3 decades. Main indicators of used water and renewable resources are given in the Table 2. In addition, the country utilizes more than 12,400 wells for groundwater extraction, of which 4,069 are under the management of the MWR, while the rest are operated by private entities and the general population. Furthermore, there are 56 water reservoirs and 13 debris basins, collectively capable of storing over 20 billion cubic meters of water (GoU, 2020a; MWR, 2023).

Most of Central Asian rivers rely heavily on glacier and snowmelt for water supply, with 80-90% of the annual flow occurring between April and October (Sadyrov et al., 2024). Glaciers and underground sources contribute 25-50% of the yearly flow. The Pamir and Tian Shan Mountain glaciers hold a massive 845 km^3 of water, seven times more than the entire annual flow in the Aral Sea Basin (Farinotti, 2015). However, the rising annual temperatures and decreased precipitation since the 1930s have caused glaciers to retreat by 25%-35% (Bolch, 2007; Farinotti et al., 2015). Over the last 50-60 years, glacier areas have shrunk by about 30% (Khamraev et al., 2020). While melting glaciers may temporarily increase runoff, it primarily boosts water resources during winter and early spring, with summer run-offs likely to decrease. Central Asia, and Uzbekistan mountain areas may also witness more floods and mudflows due to climate change, although these short-term benefits may be offset by increased precipitation variability and seasonal runoff shifts (Aizen et al., 1997; Chen et al., 2016; Sorg et al., 2019). Importantly, these changes affect downstream areas more severely, intensifying water scarcity in downstream riparian states and administrative units during drought years (Wegerich, 2007; Wegerich, 2010).

Table. 2. Main water balance parameters (2015-2021 average)

The name of indicator	10^9 m^3/year
Total surface water entering the country	102.2
Outflow to surface water to other countries	99.35
Surface water inflow	65.65
Surface water produced internally	9.54
Groundwater produced internally	8.8
Total internal renewable water resources	16.34
Total renewable groundwater	8.8
Total renewable surface water	42.07
Average water withdrawal	51-53

Source: FAO, AQUASTAT webpage

Although, water use is within 51x10^6 m^3/year as shown in Figure 6, water demand is significantly higher and is partially covered by reuse of drainage water and depends on the water inflow. From the total water demand; 50.9x10^9 m^3/year is covered by surface water flow; 0.5 km^3/year from groundwater and 1.6 km^3/year reuse of drainage water (Khamraev et al., 2020; GoU, 2020a).

1.3. Agriculture water withdrawal

Uzbekistan has historically developed a high dependency on water resources, with most of its renewable water resources located outside the republic. Irrigated areas are distributed along the main river basins, while in most parts of the country, 80% is steppe and desert.

Significant changes in water usage patterns occurred following the expansion of irrigation in the 1950s and 1960s, leading to the ecological disaster of the Aral Sea's desiccation (Micklin, 2010). Although, expansion of irrigation in Uzbekistan started in the 1950s, the main impact of the Aral Sea disappearance experienced after independence, with compounding impacts of the climate change. Water withdrawal rose during first several years, after Uzbekistan's independence mainly to increase cotton production and irrigated land explanation.

However, changes in water sharing agreements (1993 and 1997), arguments over water distribution with neighboring countries, but most importantly significant; drought of 2001 and food security (particularly replacing cotton with wheat), forced government to consider various strategies to pivot on this issue. Managing water resources remains crucial for Uzbekistan's environmental and agricultural sustainability.

Agriculture, the primary water consumer, accounts for 90% (FAO, 2024; MWR, 2023) of the water use, predominantly for irrigation purposes. This sector relies heavily on large-scale pump systems, such as those used in the Amu-Bukhara and Amu-Kashkadarya canals, as well as thousands of district-scale pumps. The comprehensive irrigation infrastructure established during the Soviet period is currently not aligned with modern energy efficiency standards, necessitating substantial investments to reduce water and energy waste. The WB classifies Uzbekistan among the world's most inefficient users of water and energy. Despite gradual improvements over the years, water use efficiency remains low (WB, 2019a; Dankova et al., 2022). Irrigation efficiency estimated at the field level amounts to 65.2% (Bobojonov et al., 2016). Regulatory practices governing water distribution, and the extensive energy consumption required for water uplift result in water withdrawal rates, exceeding 90% of the total renewable resources (WB, 2020). Unlined canals lead to significant water losses, primarily due to groundwater seepage. The flow rate of water also varies, controlled according to the timing of sowing and harvesting, leading to differences between the upper and lower reaches of the river.

Although water consumption predominantly is occupied by the agriculture, it is important to point that over the last decades, usage by other sectors such as Industry, Energy, Public utilities and Fishery has been on the rise, now sharing 10% from total water usage. MWR is forecasting that by 2030 this figure will rise to 15%, with an increase in population and urbanization from 2km^3/year to 3.5 km^3/year. And according to the law of the Republic of Uzbekistan "On Water and Water use", (GoU, 1993) the water demand by the industry is prioritized. Fishery is operated on over 595,000 hectares of water reservoir and consumes around 608x10^6 m^3 in 2018.

Water withdrawal in Uzbekistan is distributed throughout the year and increases during vegetation season for main crops, which spans from April to September. The demand for water peaks in July and August, coinciding with the highest temperatures of the year, with a significant portion directed towards irrigating cotton fields. Uzbekistan withdraws 43.2% of the Amu Darya's flow and 76.2% of the Syr Darya's flow during this period (ICWC, 2024).

Additionally, there are notable withdrawal peaks in February and March, outside the primary vegetation season. These withdrawals are primarily for leaching and field preparation. Leaching helps to mitigate soil salinity; ensuring better soil quality for crop growth, while field preparation involves various activities to ready the fields for the upcoming planting season. These early-season withdrawals are crucial for maintaining the overall productivity of the agricultural lands, underscoring the importance of water management practices that extend beyond the main irrigation period. Leaching and furrow irrigation have a significant impact on the water quality, especially to the downstream parts of the country. It is the main reason of many terminal lakes within the irrigated zone, to remove saline used water from the main river flow.

1.4. Water supply and sanitation

Industrial water usage has been relatively low at 2.68%, while slight growth has been observed in domestic and municipal water consumption with population growth and industry development. Access to and quality of water supply and sanitation (WSS) services in Uzbekistan remains a significant challenge. Much of the WSS infrastructure, built during the Soviet era, has deteriorated and requires extensive rehabilitation. Despite recent increases in public expenditure, funding has not kept pace with the need for asset replacement, maintenance, and system expansion. This has led to a decline in water service quality, particularly in rural areas and small to medium-sized towns.

Access to piped water connections is relatively high, with 98% in urban and 81% rural places, and on average 87% in the country. However, only 59% of the population receives safely managed water. This disparity is more pronounced in rural areas, where rapid population growth exacerbates access issues. Out of 119 cities, 1,064 towns, 11,088 rural villages only 69 cities (58%), 335 towns (31%) and 2,902 villages (26%) are connected to drinking water from proven groundwater deposits (Sokolov, 2023). Others are supplied with unproven reserves, wells, water conduits etc. Many water systems in these areas supply water for less than 12 hours per day due to outdated and undersized pumps, highlighting the need for closer government attention and intervention (WB, 2016).

From 2000 to 2019, the proportion of households with access to safely managed drinking water increased significantly from 67% to 87%. Additionally, official statistics indicates that access to basic sanitation facilities has been universal for over a decade (WB, 2022).

However, sewerage services remain underdeveloped outside a few urban areas, with existing systems continuing to deteriorate. Most of the sewerage infrastructure, constructed in the 1970s and 1980s, has been largely neglected and is now in poor condition. By 2016, only about 12% of the population, (approximately 3.7 million people) were served by centralized sewerage systems, a decrease from 17% in 2010 (JMP, 2019). This is mainly due to an increase in population with almost no investment in new facilities. Most sewerage connections are concentrated in Tashkent city and Tashkent region, while in other regions; only around 5% of the population is connected to a centralized sewerage system (Vinokurov et al., 2024).

Furthermore, many wastewater treatment facilities are highly degraded or nonoperational, leading to the pollution of surface water resources. Rural sanitation has largely been left to the initiative of households and communities. In these areas, most households rely on self-built on-site sanitation solutions, such as dry pit latrines or septic tanks with on-site disposal for those with indoor bathroom facilities.

This situation requires urgent need for significant investment in water and sanitation infrastructure, particularly in rural areas, to ensure equitable access to safely managed water and proper sanitation services across the country. Addressing these challenges is crucial for improving public health, reducing environmental pollution, and sustainable development.

Like many countries worldwide, Uzbekistan faces a significant challenge of drinking water scarcity. While approximately 70% of the population has access to drinking water, certain regions experience more severe shortages. The Kashkadarya, Surkhandarya, and Jizzakh regions have drinking water supplies of less than 60%. In specific areas such as Guzor, Dehkanabad, Koson, Sherabad, Angor, Gallaorol, and Khatirchi districts, this figure drops below 30%. The lowest drinking water supply indicator is recorded in the Kashkadarya region, at 43% (Daryo.uz, 2024b).

CHAPTER 2. WATER SECTOR INSTITUTIONAL FRAMEWORK

2.1. Water regulation goals and strategies

It is widely acknowledged that improving the economic potential of Uzbekistan requires more efficient use of natural resources. It is underscored by the increasing impacts of climate change, wasteful water and energy usage, and inadequate land management, all of which threaten livelihoods and future growth prospects. There shoulds be consideration of water resources regulation to the effects on national level as a food security issue, and also sectoral effects which include the Aral Sea, water resources sharing between counterparts (ADB, 2018). These issues are based on the initial and basic problem of all Central Asian countries in low water productivity in the Aral Sea Basin and outdated infrastructure (Figure 6).

Uzbekistan's key institutional issues of the water sector are due to poor incentives for efficient water use by all parties, but especially by water consumers, insufficient financial support, and limited public participation in water management (Khamraev et al., 2020). The system relies on administrative methods, with water quotas and crop patterns often determined by discretion rather than economic efficiency. State funding covers most water delivery costs, while payments by agricultural producers are not linked to water usage, providing little motivation for efficient use (GoU, 2020a). The payments are not sufficient to encourage productive and efficient water use.

Uzbekistan's main and inter-farm water infrastructure is managed by state entities and funded by the state budget, thus, lacks incentives for cost-saving and modernization by water consumers. Public-private partnerships are underutilized, and Water Consumer Associations (WCAs) have failed to become self-sustaining, leading to poor maintenance and services. Water management responsibilities are fragmented across multiple ministries, resulting in inefficient use and poor coordination. Improved integrated planning and coordination among agencies would enhance water security and sector sustainability (Figure7).

Uzbekistan has set multiple goals to enhance water regulation, reduce water waste, and increase pump productivity to achieve the UN Sustainable Development Goals (SDGs) and transition to greener growth. To achieve the set goals in 2019, several laws and restructuring of the governing bodies were put into law (GoU, 2020a).

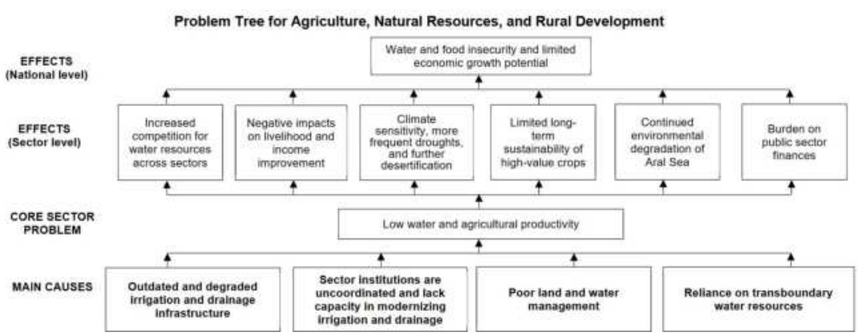


Figure 7. Problem tree for agriculture, natural resources and rural development

2.2. Legislative framework

The primary national legislative act governing water relations in Uzbekistan is the Law of the Republic of Uzbekistan "*On Water and Water Use*" dated May 6, 1993 (GoU, 1993), which has been amended and supplemented in 1997, 2009 and 2017 (Khamraev et al., 2020).

The law establishes water regulation and management and covers almost all parts of water use and distribution. It outlines the roles and responsibilities of state authorities, the procedures for managing water use, and the protection of water resources. Key areas covered include; the design, construction, and operation of structures that impact water bodies, the classification of water use, and the rights and obligations of water users. It also addresses specific uses of water, such as for drinking, agriculture, industry, and navigation, along with interstate water management within the Aral Sea basin. It covers activities within protection zones, roles of water users and consumers, and classification of water use types. It further details the procedures for granting rights to use water bodies, along with the associated rights and obligations of water users. Additional topics include dispute resolution, liability, compensation for damages, and international cooperation in water regulation.

Water use and consumption, including the establishment of water withdrawal and application for water limits (quotas), are regulated by the "*On the approval of some administrative regulations for the provision of the state services in the field of nature use*." This regulation, effective from April 1, 2018, was approved by the Resolution of the Cabinet of Ministers of the Republic of Uzbekistan (GoU, 2018c).

Additionally, a new Decree of the President of the Republic of Uzbekistan, (GoU, 2024) seeks to regulate water management and increase efficiency of the water use. This law establishes Water Supply Services, within the district level irrigation system departments, which should control water supply for the consumers and maintain irrigation networks, while keeping accounting for the water usage and gather water usage tax.

Water usage prices are regulated by the Law of the Republic of Uzbekistan and considers government standards of water requirements for various crop-water requirements (GoU, 2023).

Resolution No.430 (GoU, 2017) sets guidelines for well construction and groundwater extraction, while *Resolution No. PP-3823* (GoU, 2018a) establishes varied groundwater pricing based on user categories. Additionally, *Resolution No. 855* (GoU, 2019b) introduces new protocols for overseeing and restricting groundwater withdrawal in three pilot districts (Schmidt et al., 2024).

Resolution of the Cabinet of Ministers of the Republic of Uzbekistan, No. 320 (GoU, 2018b) stipulates electricity subsidy that addresses issues of water delivery directly to the farms by the pumps and responsibility of the agencies in covering expenses.

The law of the Republic of Uzbekistan on drinking water supply and sewerage system (GoU, 2022c) access, regulates all aspects of consumer, regulator and drinking water facilities work, as well as levels of drinking water consumption.

Although the main law on *"On Water and Water Use"* (GoU, 1993) covers almost all aspects of the water regulations, it does not address financial sustainability, public-private partnership legislation and performance issues.

In strategy of the irrigation and water resources development for 2030, these issues were highlighted and brought into attention. Recently the first draft of the Water Code passed through the Oliy Majlis, Uzbekistan's parliament (Daryo.uz, 2024, Kun.uz, 2024b). The Water Code will address:

- Centralization of Water Management to ensure streamlined and efficient management;
- Encouragement of Public-Private Partnerships (PPP) to boost investment and innovation in the water sector;
- Simplification of Regulatory Framework, to reduce bureaucratic procedures;
- Ensuring cost recovery for water suppliers;
- Improved Accountability and Performance. Increasing the responsibilities of both water suppliers and consumers to enhance overall efficiency.

Another key feature is the shift from referral norms to direct action norms, which will result in the cancellation of various existing resolutions and procedures, thereby simplifying the regulatory environment. Overall, the adoption of the Water Code is expected to enhance water management, increase the efficiency of water use, and promote accountability among suppliers and consumers. By centralizing control, simplifying regulations, and promoting investment, the code aims to modernize the water sector, ensuring sustainable and effective water resource management while fostering accountability and innovation.

National governance of water use in Uzbekistan involves a several administrative structures comprising of various levels of government and specialized state bodies (Khamraev et al., 2020). The main authority is the Cabinet of Ministers of the Republic of Uzbekistan, which formulates national priorities in development of further applying overall country-based goals on the water policies and ensures their implementation across the country.

Local government bodies, including regional and municipal authorities, play a crucial role in the decentralized management of water resources. These entities are responsible for overseeing water distribution, usage, and conservation within their respective jurisdictions. They work in coordination with the national government to ensure that local water management practices align with national policies and regulations.

2.3. Water resource management – institutional structure

As per Uzbekistan's "Law on Water and Water Use," the governance of water use is managed by the Cabinet of Ministers of Uzbekistan, local government authorities, and specific state bodies, either directly or through basin administrations and other government entities.

The Ministry of Water Resources is tasked with the direct regulation and oversight of national policy of water resources management and use, and efficient water use

(Figure 8). The Ministry operates through Basin Administration of Irrigation Systems (BAIS), which manages water resources on a watershed basis and large canals. Basin administrations are responsible for developing and implementing water management plans that address the unique needs and challenges of their specific regions, including managing all large-scale water infrastructure and ensuring the effective use of water resources at the basin level (Hamidov et al., 2015; Hamidov et al., 2020). This approach allows for more targeted and effective management of water resources, considering the geographical and environmental characteristics of each basin.

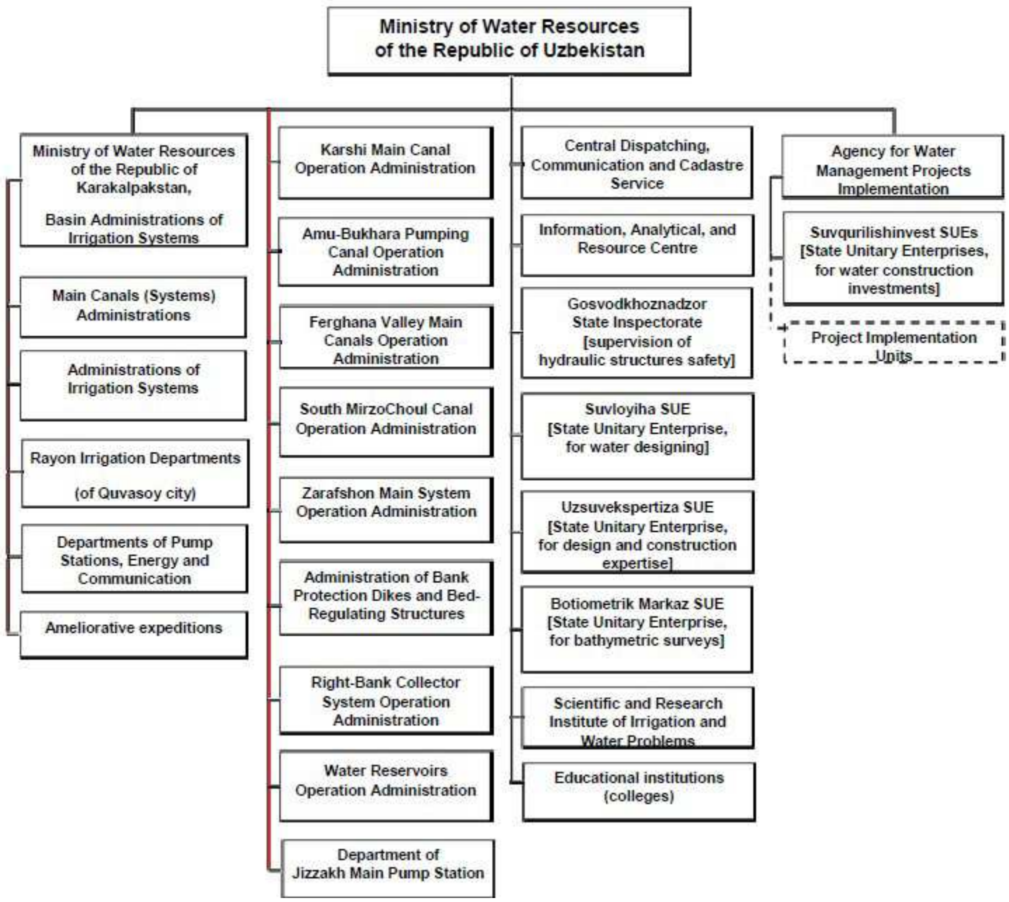


Figure 8. Institutional Structure of the Ministry of Water Resources

The Administration of the Irrigation Systems (AIS) comprises state bodies responsible for setting and enforcing water withdrawal limits (quotas) and monitoring compliance with regulations (Figure 9). These bodies play a crucial role in the collection, control, and analysis of hydrological data, which is essential for informed decision-making and policy development. They also promote the adoption of advanced technologies and best practices in water management to enhance efficiency and sustainability (Sokolov, 2023).

In recent reforms, basin irrigation systems authorities were reorganized along regional lines, replacing the previous water management organizations that operated within district administrative boundaries. This reorganization aims to improve the management and distribution of water resources, ensuring a more coordinated and effective approach to addressing regional water needs and challenges (GoU, 2020a; ADB, 2022).

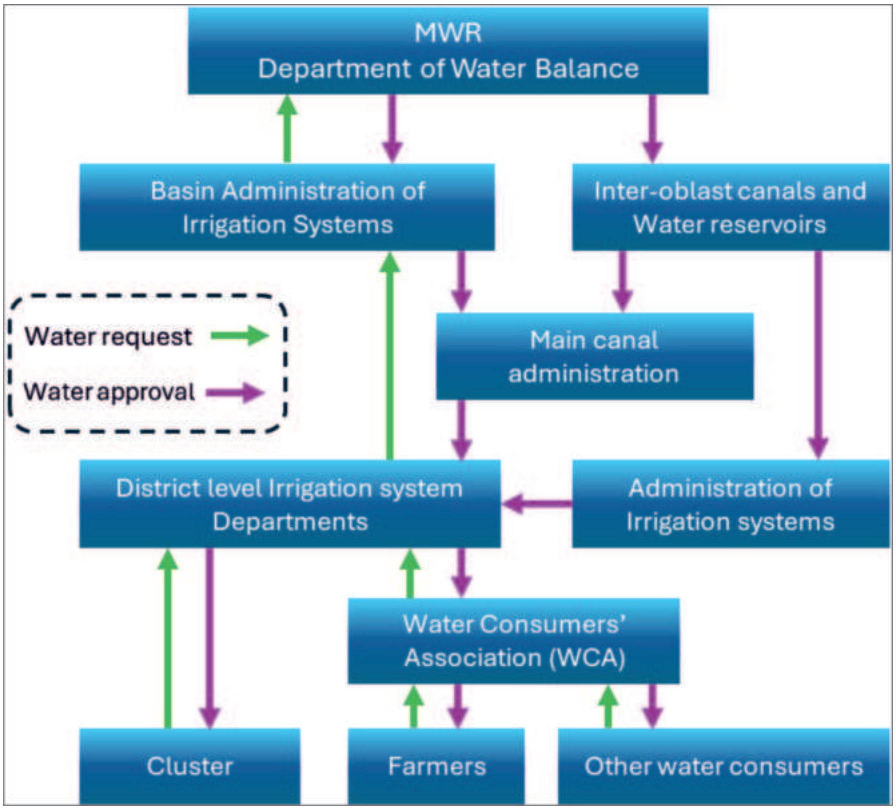


Figure 9. MWR structure of administrative operation

Large irrigation canals, such as the Amu-Bukhara Pumping Canal and the Fergana Valley Canal, along with major water reservoirs, are operated and controlled by separate institutional bodies. These bodies are responsible for the operation and maintenance of the main inter-district canals. Meanwhile, district irrigation departments handle water allocation planning and the operation and maintenance of the inter-farm canals. This organizational structure ensures that both large-scale and local water distribution needs are effectively managed, supporting the overall efficiency and sustainability of the irrigation system. (GoU, 2020a).

Farmers and other end-users are organized into the Water Consumers' Association (WCA), formerly known as the Water Users Association (Hamidov, 2020). The

WCA determines water requirements based on the crop production requests of the farmers, and these requirements are then communicated to the District Level Irrigation Systems. This district-level body is responsible for collecting fees from users and managing clusters, which are groups of farmers united by their common crop production interests.

The WCAs are responsible for the operation and maintenance of secondary canals and the collection of irrigation service fees from water users. Additionally, WCAs manage selected inter-farm canals under contracts with district irrigation departments. Farmers themselves manage the on-farm networks. Significant reforms in 2019 restructured WCAs along district administrative boundary lines to enhance efficiency and coordination in water management. (GoU, 2019). (ADB, 2022).

Agricultural clusters that were introduced in 2019 are actively created in the country, some of which have taken their own responsibility for managing water resources within their areas.

In several regions, the Ministry of Ecology and Environmental Protection and Climate Change evaluates the ecological condition of groundwater reserves. Based on the assessment by the Ministry of Mining Industry and the applicant drilling company, groundwater extraction levels, ecological status of the reserves, and the irrigation water needs of the applicant, a quota or maximum groundwater abstraction limit is assigned to water users (Schmidt et al., 2024). Operational rule depends on purpose of the use, depending on the well operation and capacity as well as depth of the well. Wells that are less than 25 meters deep and capacity lower than $5m^3$ per day are exempt from the regulation and do not require permits (Knorr et al., 2021). Although, this regulation still has various interpretation as very few are registered in the Ministry of Mining Industry and Geology, choosing instead registration in local administrations (hokimyats). It gives easier documentation to build in addition to the electricity connection for the pump (Schmidt et al., 2024).

Large commercial farms, which typically operate one or more wells, receive subsidized electricity quotas based on their land area and the crops they grow. In contrast, dehkan farms, which are smaller land users, collectively utilize groundwater for irrigation during periods of scarcity. These small farms have established informal agreements to share the technical maintenance of groundwater infrastructure, technology, electricity costs, and groundwater resources equitably throughout the irrigation season.

2.4. Main agencies involved in the water sector governance

According to legal mandates, specific state administrative bodies are designated to regulate water use within their respective areas of expertise. These bodies, operating within the scope of their competencies, include:

Ministry of Water Resources of the Republic of Uzbekistan; is responsible for the regulation and management of surface waters, overseeing the utilization and conservation of rivers, lakes, and reservoirs, including construction of the water management and distribution facilities; its operation and scientific research. It addresses transboundary water sharing and regulation, controls application and water distribution and regulation depending on signed agreements. The ministry is also responsible for the water quality and shallow water table monitoring, as well as drainage water control and management. Currently, the MWR has the following subordinate organizations: Ministry of Water Resources of the Republic of Karakalpakstan, 12 Basin Administrations of Irrigation Systems, 53 Administrations of Irrigation Systems and Main Canals, 152 District Irrigation Departments (DID), 14 Pumping Stations and Energy Departments, 13 Hydro- meliorative Expeditions, and others (GoU, 2020a).

Ministry of Mining Industry and Geology of the Republic of Uzbekistan tasked with the management of groundwater resources, this committee ensures the sustainable extraction and use of deep underground water reserves, including artesian wells. The ministry responsibilities include monitoring deep groundwater levels, quality, and the implementation of policies to prevent over-extraction and contamination. The ministry controls mineral and artesian (deep) wells and groundwater.

Ministry of Housing and Communal Services of the Republic of Uzbekistan, particularly OzSuvTaminot JSC overseeing improvement of water supply and sewerage systems and rational use of drinking water, construction and maintenance of water supply and sewerage facilities.

These above bodies collaborate to form a comprehensive regulatory framework that addresses the diverse aspects of water resource management in Uzbekistan. Their coordinated efforts are crucial for maintaining the balance between water supply and demand, protecting water quality, and ensuring the sustainable use of the country's water resources for various economic, environmental, and social needs.

The state's supervision over the water use and protection is carried out by *Local government authorities*, *Ministry of Ecology and Environmental Protection and Climate Change of Uzbekistan*, for ecological conditions and environmental impact. In addition, *Uzhydromet* provides forecasts for water availability and meteorological conditions. Ministry of Health of Uzbekistan is responsible for overall health condition, including sanitary-epidemiological control and supervision of water.

2.5. International and cooperation agencies

Inter-agency cooperation is a key component of national water governance in Uzbekistan. Various state bodies collaborate to address transboundary water issues.

The ICWC (Interstate Commission for Water Coordination of Central Asia) was established on February 18, 1992, by an agreement between Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, and Uzbekistan (Figure 10), with the main goal of adopting principles of collective decision making on common water-related issues and on measures for implementation of joint programs, while respecting the interests of the parties.

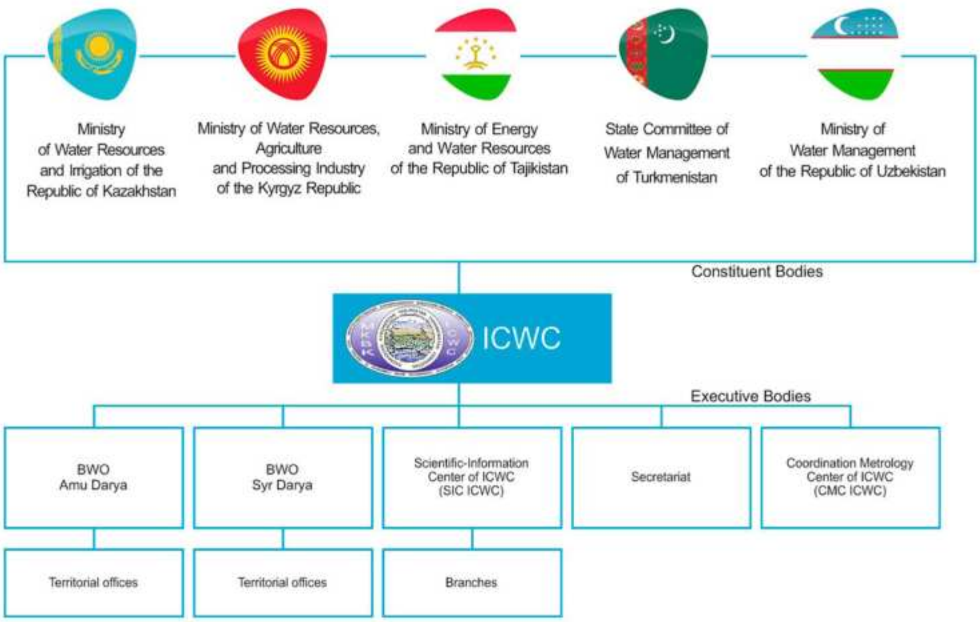


Figure 10. Structure of ICWC

The ICWC, acting on principles of equity, equality, and consensus, was later incorporated into the IFAS (International Fund for Saving the Aral Sea) as an international organization (Figure 11).

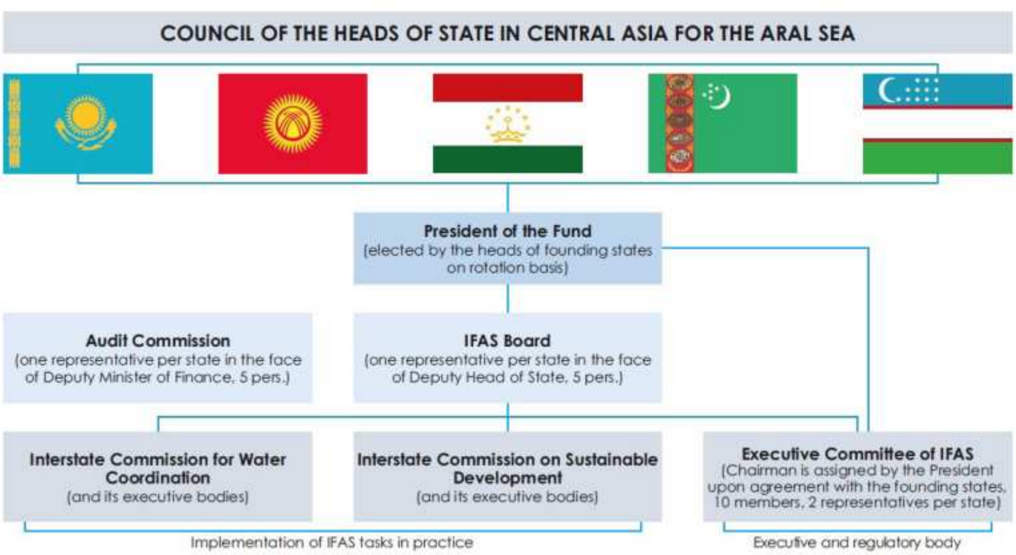


Figure 11. Structure of the IFAS

ICWC's executive bodies include the River Basin Authorities (BWOs) for the Syr Darya and the Amu Darya Rivers, the Scientific-Information Center (SIC ICWC), the Coordination Meteorological Center (CMC ICWC), and the Secretariat. BWOs handle water flow schedules, distribution, and quality control, while SIC ICWC focuses on information analysis, developing water management methods, and improving ecological conditions in the basin.

SIC ICWC collaborates with scientific and design organizations across Central Asia, maintaining national branches to facilitate scientific and information exchange. It processes and disseminates global information on water sectors within Central Asia.

The IFAS summits provide the countries of Central Asia with a unique platform for regular political dialogue at the highest level on water management and environmental issues and thus unite joint efforts for further prosperity and sustainable development in the region.

International partnerships and agreements also play a significant role in Uzbekistan's water governance, as the country shares many of its water resources with neighboring states. Collaborative efforts with international organizations and foreign governments help to address shared water challenges and promote regional stability and cooperation.

CHAPTER 3. CLIMATE CHANGE AND WATER MANAGEMENT

3.1. Agricultural water use

Uzbekistan's agriculture is water-intensive, requiring substantial irrigation, as main agricultural centers are located within river valleys in arid and semi-arid climate conditions. Due to low precipitation and high evapotranspiration rates, the country relies heavily on water from major rivers like the Amu Darya, Syr Darya, Zaravshan and others to sustain its agricultural sector.

Agriculture in Uzbekistan's economy contributes around 24.3% to the national GDP and employs 28% of the workforce as of 2018 (Khamraev et al., 2020). From 20,2363x10^6 hectares of agricultural lands 3,9885x10^6 hectares are arable lands (Sokolov, 2023; Khamraev et al., 2020; Umerbekov et al., 2023). Crops in the Aral Sea Basin countries, dominantly represented by cotton and wheat heavily rely on supplemental irrigation for yields.

In the country, various irrigation methods, including 64% furrow, 31% strip and 5% basin irrigation are employed. Despite recent canal reconstruction projects, more attention from governments is needed to curb these losses. The flow rate of water also varies, controlled according to the timing of sowing and harvesting, leading to differences between the upper and lower reaches of the river. The continued use of these outdated irrigation systems has detrimental consequences, including soil erosion, salinization, and waterlogging. This not only threatens agricultural sustainability but also long-term food security for rural communities. Waterlogging and salinization are widespread issues affecting cotton and wheat growing in Uzbekistan.

These high-water dependencies and scarcity as well as transboundary sources of freshwater resources cause serious worries within international and local communities. Uzbekistan will reach water scarcity levels by 2030 considering current level of population growth, climate change impact and demand (WB, 2016). Uzbekistan is already considered to be under significant water stress in current climate conditions (World Population Review, 2024). Additionally, high aridity, and increased drought risks with heat waves could cause compounding effect disasters in dust storms (Nishonov et al., 2023), including salts from the dried bottom of the Aral Sea.

Maintaining existing infrastructure, including water, sanitation, gas, and electricity services, is a significant challenge. The basic service and utility infrastructure was largely constructed in Uzbekistan during the Soviet era. Many of these local systems have exhausted their useful lives and require extensive rehabilitation and renewal (WB, 2022).

Inter-farm irrigation network extends to 28,940 km, while farm and on-farm networks cover 155,000 km. The total drainage network of which is 142,800 km long, consisting of 106,100 km of open drains and 36,700 km of closed (subsoil) horizontal drains. The Ministry of Water Resources also manages 172 ameliorative pumping stations, 3,788 vertical drainage wells, and 27,648 observation wells to maintain favorable soil reclamation conditions and groundwater levels on irrigated lands. For irrigation, 1,687 pumping stations, equipped with more than 5,285 pump units consuming $8x10^9$ kWh annually, are operated by the MWR. Additionally, over 10,280 pumping units are used on the on-farm irrigation networks (Khamraev et al., 2020; GoU, 2020a).

Uzbekistan's government is gradually trying to address these issues by implementing initiatives for water-saving technologies in more sophisticated water monitoring till final users (installation of farmer level water control instruments), integration of drip irrigation into agriculture and others. With current water allocation quotas, Uzbekistan considers distribution of 63.02 $x10^9$ m^3/year (MWR, 2018), while total demand is higher than that and equals to 64.2 $x10^9$ m^3/year (Table 2).

Formal access and withdrawal rights exist in the form of drilling permit (i.e., special water permit) requirements for boreholes deeper than 25 m or expected extraction higher than 5 m^3/day. The permits can be issued by the Ministry of Mining Industry and Geology to drilling companies if it's deeper than 25 meters. From 1st January, 2024, wells are required to have digital water consumption monitoring, consumption of less than 5 m^3 per day are exempt from this requirement (Daryo.uz, 2023c; https://upl.uz/economy/37969-news.html). This part is regulated by the Decree of the President of the Republic of Uzbekistan no. PP-439 (GoU, 2022a; Knorr et al., 2021; Schmidt et al., 2024)

3.2. Water supply

Over the last decades, particularly from the 1980s, annual water withdrawal and consumption has been gradually decreasing (Figure 12), reaching from 66.1 km^3 in 1980s to 53 km^3 in 2010s, although, increased to 58 km^3 in 2020 (FAO, 2024). Dry and wet years can also correct this number, as in dry years Uzbekistan receives on average 70-75% from overall demand. Climate change is likely to cause more severe and prolonged droughts, decreasing water availability and underscoring the need for effective planning and adaptation for water security (Xenarios et al., 2018; WB, 2024). It is therefore an utmost importance for careful long-term planning and integrated water resource management to addressing increasing climatic risks and high water demands, especially in agriculture, which accounts for about 90% of total usage.

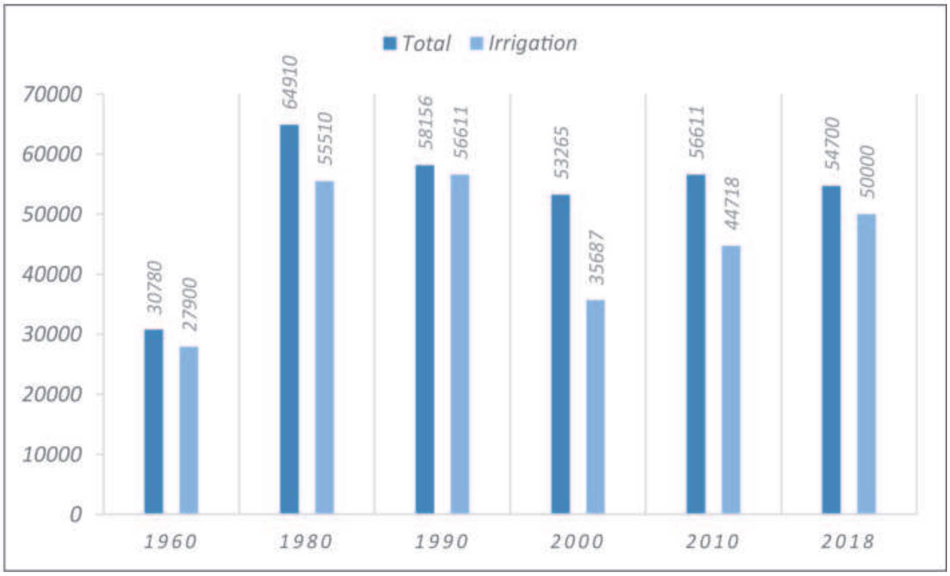


Figure 12. Dynamics of actual water withdrawal from rivers (10^6 m^3)

Source: FAO, AQUASTAT, Khamraev et al., 2020)

With population growth and fast development of the urban areas, demand for domestic water supply will also increase. However, groundwater serving as the main source for this purpose is intensively polluted due to increased salinization and drainage network being overwhelmed or not maintained properly. Some regions, including major cities (Bukhara, Karshi, Navoi or Zaravshan), depend on water transported over long distances from remote mountainous catchment areas, large reservoirs, or deep aquifers.

3.3. Overall climate change impact to the water resources availability

The dependence on river flow from the Syr Darya and Amu Darya rivers for irrigated agriculture is crucial. Climate change will continue to have a significant impact on available water resources and their seasonality. Uzbekistan's water resources comes primarily from rivers that rely on glacier and snowmelt for their water supply, with 80-90% of the annual flow occurring between April and October. These glaciers are mostly located outside Uzbekistan's territory. Glaciers and underground springs provide 25-50% of the annual flow. The glaciers of the Pamir and Tien Shan contain a massive 845x10^9 m^3

of water, seven times more than the entire annual flow of the Aral Sea basin.

However, the rising annual temperatures and decreased precipitation since the 1930s have caused glaciers to retreat by 25-35% (Bolch, 2006; Farinotti et al., 2015, Sadyrov et al., 2023). This alarming trend could potentially result in severe water shortages, posing a substantial challenge for the region's agricultural sustainability and water resource management. Melting glaciers may temporarily increase runoff, as it primarily boosts water resources during winter and early spring, with summer run-offs likely to decrease. Central Asia may also witness more floods and mudflows due to climate change, although these short-term benefits may be offset by increased precipitation variability and seasonal runoff shifts (Aizen et al., 1997; Sorg et al., 2012; Chen et al., 2016). Importantly, these changes affect downstream areas more severely, intensifying water scarcity in downstream riparian states and administrative units during drought years (Dukhovny et al., 2021; Wegerich, 2007; Wegerich, 2010).

Climate change at the regional scale in Central Asia has been significantly influenced by major shifts in agriculture, urbanization, deforestation, alterations in natural ecosystems, and the rapid degradation of the Aral Sea (Lioubimtseva & Henebry, 2009; Kariyeva & van Leeuwen, 2011). These changes are crucial in shaping the region's climate dynamics.

Agricultural expansion and further drying up of the Aral Sea alters the surface's albedo, which affects how solar radiation is reflected and absorbed. This, in turn, impacts local temperatures and microclimate patterns. In addition, population growth and further urbanization increases impervious surfaces, leading to changes in temperature, evaporation rates, and runoff. The degradation of the Aral Sea adds another complex layer to the region's climate dynamics. The substantial shrinkage of this once-massive lake has exposed large areas of dry, salty lakebed, which absorbs more solar radiation and contributes to local and regional temperature increases. Additionally, the desiccation of the Aral Sea releases large amounts of fine dust and salts through sand-dust storms, affecting air quality and human health in the region.

An analysis of temperature data from 1950 to 2011 indicates an average rise of 0.27°C per decade (Hu et al., 2014). During this period, the annual temperature range contracted, with average minimum temperatures increasing by 2.0°C and average maximum temperatures by 1.6°C.

The warming trend exhibits regional variability across Uzbekistan. The most pronounced increases were observed in the northern regions and urban centers, with temperature rises ranging from 0.30°C to 0.43°C per decade. In contrast, the mountainous areas experienced relatively milder warming, with rates between 0.10°C and 0.14°C per decade. Seasonal analysis reveals that spring and autumn experienced the most substantial temperature increases, at 0.39°C and 0.31°C per decade, respectively. Winter temperature increases were comparatively modest, averaging 0.13°C per decade.

Significant long-term mean temperature increases, exceeding 1.0°C, were particularly concentrated in the colder months. As a result, winters and springs have warmed by an average of 1.3°C compared to the period from 1960 to 1990 (Kholmatjanov et al., 2020).

Air temperature changes in Uzbekistan; reveal an intensified warming trend since 1990 across the entire region. While all months showed an increasing trend, summers have also become notably hotter. The warming trends were especially pronounced in the northwest and nearly all oasis zones of Uzbekistan, suggesting a stronger anthropogenic impact compared to the less-populated desert and mountainous areas. This highlights how human activities have contributed to regional temperature increases, particularly in densely populated and cultivated areas.

Precipitation trends indicate an overall increase in the region, particularly in the northern areas, while southern regions may experience slight decreases. Spring and autumn are expected to see increased precipitation, whereas summer precipitation may decrease. This could result in more wet winters with more frequent occurrences of precipitation and drier springs, summers, and autumns (Luo et al., 2018; Jiang et al., 2020).

The primary drivers of the temperature trend in Uzbekistan are linked to changes in regional atmospheric circulation, raising concerns about their potential future impacts. According to the climate change projections, the temperatures in the region are expected to rise under all scenarios (Pachauri et al., 2014; Shukla et al., 2019). However, the precise direction and magnitude of changes in precipitation and river water flows remain less certain. Projections suggest a median temperature increase of approximately 3.7°C by the end of the century, with substantial warming anticipated during the summer months.

Projections suggest that Uzbekistan may face chronic meteorological drought by the 2090s. Although, average annual precipitation has not shown significant changes in recent decades (Hu et al. 2014; Hu et al. 2015), climate models predict varying outcomes, ranging from a 30% reduction to a 20% increase in annual precipitation. Global trends indicate that extreme rainfall events may become more intense with rising temperatures, potentially increasing the total precipitation during extreme five-day events by 0-20%, depending on the emissions scenario (Luo et al. 2018; Jieng et al., 2020; Gummadi et al., 2024). Severe drought could occur in 87% of all years by the 2090s (WRI, 2023). Increasing of water stress is also forecasted in western Uzbekistan (Rakhmatova et al., 2024).

By the 2040s and 2050s, climate change may cause severe water shortages along the Amu Darya and Syr Darya rivers due to rising temperatures and accelerated glacier melt. The temperature increases of 2.2°C to 3.1°C in Tajikistan's mountainous areas could reduce glacier mass by 36% – 45%, altering seasonal river flows and shifting peak flows from summer to spring (Farinotti et al., 2015). Additionally, climate change impacts such as extreme heat, drought, flooding, landslides, and wildfires are expected to significantly affect energy generation, especially from hydro resources, as reduced snow cover and increased evaporation exacerbate water and energy shortages (Narbayev & Pavlova, 2022).

The water resource sharing between upstream and downstream countries has always been subject of negotiations. The water distribution management was regulated only among former Soviet Union countries; with the Almaty Agreement (FAO, FAOLEX database, 2024) from 1992, as Afghanistan hadn't had any significant resources to divert waters. However, the construction of a new canal in Afghanistan from 2022, extending to 285 km, 100 meters in width, and 8 meters in depth, has the potential to alter the dynamics of water allocation in the region significantly.

The canal is funded by public funds of Afghanistan. Upon completion, it will supply irrigation water to 550,000 hectares in four provinces (The Economist, 2023). Afghanistan plans to complete construction works within 2-4 years by 2025 (Saida, 2023). By the end of 2023, more than 100 km of the canal was completed through deserted areas.

Water allocation in the complex Amu Darya River Basin should develop an assessment framework that considers environmental, social, and economic dimensions. The additional distribution of water in different parts of the Amu Darya increases the potential vulnerability of water resources from the construction of the canal, which requires close cooperation between the parties (Khujanazarov et al., 2024). The construction of the canal shall be carefully planned, and during construction work, to avoid risk of water seepage and water losses. Extensive waterlogging and salinization of the surrounding ecosystem also impacts on agricultural productivity due to the accumulation of excess salts in the soil and waterlogged conditions (Kijne, 2005).

Establishing a robust framework to assess the vulnerability of regions affected by alterations in water allocation, especially considering the reduction of irrigation water for downstream countries is imperative for implementing effective adaptation measures. This need is underscored by the significant reliance of Uzbekistan and Turkmenistan on irrigation water for their GDP (Varis, 2014), highlighting the economic implications associated with changes in water distribution. Environmental factors, including ecosystem health, biodiversity, agriculture, livelihoods, and community resilience, should be integral components of the assessment. This inclusive evaluation aims to provide a nuanced understanding of the multifaceted impacts for adaptive strategies.

CHAPTER 4. WATER TARIFFS AND INVESTMENTS

4.1. Public investments

Uzbekistan's approach to public investments in water infrastructure is both comprehensive and strategic. By increasing funding, adopting advanced technologies, and improving international partnerships, the government is addressing inefficiencies while laying the groundwork for long-term sustainability. These efforts show the nation's commitment to securing its water resources and ensuring the sustainable development of its agricultural sector.

In recent years, Uzbekistan has made serious progress in enhancing its water infrastructure through significant public investments. Recognizing the pivotal role of efficient water management in the nation's agricultural and economic stability, the government is committed to a significant increase in funding for water infrastructure projects. For the year 2024, planned investments include 134.5 million USD from centralized investment funds and an additional 300 million from international financial organizations (MWR, 2023; Daryo IP, 2023a). These investments are aimed at addressing the inefficiencies and wastage prevalence in the current irrigation systems.

One of the cornerstone initiatives of this investment strategy is the adoption of a comprehensive three-year program for lining irrigation canals. This initiative is critical as it aims to reduce water wastage, which is currently estimated at approximately 40% due to inefficient operation and insufficient concrete coverage of ditches (MWR, 2023). There is an urgent need to address this wastage, which results in the loss of around 6-6.5x10^9 m^3 of water annually. To tackle this, regional governors and water management systems have been tasked with lining more than 300 canals with concrete, a measure expected to significantly curb water loss (Daryo.uz, 2023b).

In addition to infrastructural improvements, Uzbekistan is expanding the implementation of water-saving technologies. Currently, these technologies are deployed on 1.2 million hectares of land, with plans to extend their use by an additional 300-400 thousand hectares annually, targeting coverage of 2 million hectares by 2030. This expansion is crucial in mitigating the anticipated water deficit of 7x10^9 m^3 projected by 2030. To promote improved water productivity, the government has also implemented a water-saving technology program, approved by Presidential Decree (GoU, 2020b). This program incentivizes water and energy conservation, covering up to 40% of drip irrigation costs and exempting farmers from land tax for five years (Liutin, 2023). Until 2019, only 3 enterprises were operating in the country, with the local production of water-saving irrigation technology equipment and components. However, today, the number of such enterprises has increased to 50. These technologies have proven to be highly effective in reducing water consumption by 40-50%, mineral fertilizers by 25-30%, fuel-lubricants by 30-35%, and labor costs by 25%. Furthermore, they have also increased productivity, including in cotton growing, by 30%. (SUEZ, 2023).

Financially, the state's commitment to the agriculture and water industry is evident. As of January 1, 2023, the state budget allocated to these sectors stands at 2.54 billion USD (Vinokurov et al., 2023). This substantial allocation shows the financial commitment required to modernize the country's water infrastructure. Additionally, efforts to digitize canal management systems are underway with integration of the modern water control systems. The government set a goal to install online operating systems in all regions, starting from Fergana valley, Samarkand, Syrdarya and Kashkadarya. Works are expected to be completed till 2026, currently, 26 locations within the Kashkadarya region have enhancing the efficiency and management of water resources. Online water monitoring systems have already been installed in main canal and drainage channels throughout Uzbekistan.

Despite these advancements, the current inefficiencies and outdated irrigation methods contribute to massive loss of water annually. This highlights the critical need for ongoing investments in water-saving technologies and infrastructural improvements. Moreover, the government is not only focusing on physical infrastructure, but also on institutional reforms to enhance water management. This includes training programs for local water management authorities and farmers, on the latest water-saving techniques and efficient irrigation practices. By fostering a culture of innovation and efficiency, Uzbekistan aims to create a sustainable water management system that can adapt to future climatic and economic challenges (GoU, 2020b).

4.2. Public- Private Partnership (PPP) initiatives

Uzbekistan's economic revitalization since 2016 has significantly leaned on private sector participation, underscored by an ambitious Public-Private Partnership (PPP) program. This strategic shift, aims to bridge the country's substantially old infrastructure across various sectors, including energy, utilities, transport, water management, and others. Between 2019 and 2022, the Uzbek government, through the PPP Department, initiated 265 PPP projects valued at 2.9 billion USD. These initiatives are distributed across critical sectors, reflecting a diversified approach to infrastructural development. The National Strategy for 2022-2026 targets attracting 14 billion USD in private investments specifically into the transport, energy, health, education, and water supply and sanitation (WSS) sectors. From 2020 upwards, the number of PPPs in the water sector is dynamically increasing and is projected to reach 50 by 2030. Water code law that is in under consideration will address involvement of the private sector into the water infrastructure investment and thus create a base for the future development on PPP initiatives in Uzbekistan.

To streamline these efforts, the government introduced a roadmap via the Decree of the President of the Republic of Uzbekistan (GoU, 2022b). This decree outlines the actions and timelines for 28 specific projects planned between 2022 and 2024, covering power, education, transport, health, utilities, solid waste, and water sectors. Significant administrative reforms in 2022 restructured the PPP; Development Agency was changed into the PPP- Development Department. This department now includes a new unit focused on reducing the state's role in infrastructure services, thereby fostering an environment conducive for private sector participation and investment.

Most PPP projects in Uzbekistan have been structured with substantial support from international financial institutions (IFIs), showing confidence in Uzbekistan's strategic direction. The involvement of IFIs ensures that the projects adhere to international standards and best practices, contributing to their success and sustainability (Table 4). Projects scheduled for 2023 are in various stages of development (Komilov, 2024, ADB report 2022, Vinokurov et al., 2023).

Implementing market mechanisms in water resources management aims to reduce operating costs by at least 15% and foster public-private partnerships in the water sector. According to Article 367 of the Tax Code of Uzbekistan, land under drip irrigation systems is exempt from land tax for five years. Moreover, areas adopting water-saving technologies can receive a 30% water tax discount upon installing water meters (Suez.com, 2023).

Table 4. Projects in the water sector supported by international funds

Partner	Project Name	Duration	Amount mln. USD
ADB	Ak Altin Agricultural Development Project	2001 - 2010	72
ADB	Ak Altin Agricultural Development Project	2001 - 2010	112.6
ADB	Land Improvement Project	2007 - 2015	76.2
ADB	Water Resources Management Sector Project, Zarafshan and Ferghana Valley	2008-2016	144.1
ADB	Amu-Bukhara Irrigation System Rehabilitation	2013 (ongoing)	406.3
IBRD	Ferghana Valley WRM Project - Phase II	2017 (ongoing)	213.6
IsDB	Reconstruction of Main Irrigation Canal of Tashsaka Irrigation System	2012 (ongoing)	144.2
IsDB	Improvement of WRM (Khazarbag–Akkapchigay Canal Reconstruction)	2014 (ongoing)	122.7
KFAED/ IsDB/OPEC*	Rehabilitation of Irrigation and Drainage Network in Djizak and Syrdarya	2007 - 2014	94.3
SDF	Restoration of Karshi cascade of pumping stations - Phase III	2018 - 2020	115.9
WB	Ferghana Valley WRM Project - Phase I	2009 - 2016	81.9
WB	Ferghana Valley WRM Project - Phase II	2016 (ongoing)	211
WB	South Karakalpakstan WRM Improvement	2014 - 2020	376.7
WB/IDA	Uzbekistan Drainage Project	2003 - 2013	74.55
WB	South Karakalpakstan WRM Improvement	2014 - 2020	376.7
WB	Bukhara and Samarkand Sewerage Project	2015 (ongoing)	105
WB	South Karakalpakstan Water Resources Management Improvement Project: Rehabilitation of Ellikkala 1 Canals	2020 - 2021	8.825
WB	Water Services and Institutional Support Project	2020 - 2027	246.8

Sources: ADB, 2022; WB, 2020 ; * Kuwait Fund for Arab Economic Development.

Uzbekistan's public-private partnership initiatives reflect a robust framework aimed at leveraging private sector efficiency and investment to meet the nation's infrastructure needs. These efforts are critical for sustainable development, enhancing service delivery, and improving the quality of life for its citizens. The country also addresses need to reduce budget funds by 30% in implementing market principles to the water infrastructure investment.

4.3. Water Tariffs and government policy

Water usage prices are regulated by the Law of the Republic of Uzbekistan, No. ORQ-891 (GoU, 2023), and simply considers government standards of water requirements, for various crop water requirements, further charging 100UZS/ m^3, or 0.0079 USD, although not all canals have measurements to define how much water were delivered.

It is important to include a resolution for the farm level pump electricity subsidy that addresses issues of water delivery directly to the farms and responsibility of the agencies in covering these expenses (GoU, 2018b).

The formal price for GW is UZS 124.8/ m^3 (0.01 US$). Water users must pay for actual water use, if a water meter is installed or a flat price for water equal to the price per m^3 of water multiplied by the maximum volume of GW specified in their permit (Knorr et al., 2021). Furthermore, the government grants the status of specially protected natural territories to fresh GW formation zones to protect reserves. The State Committee on Ecology and Environmental Protection, in cooperation with the State Committee for Geology and Mineral Resources, Ministry of Agriculture, and Ministry of Water Resources are responsible for the identification of potentially ecologically dangerous objects located within the boundaries of protection zones and developing measures to prevent pollution and depletion of fresh GW (Resolution of the CoM No 23 "On assigning the status of special protected areas to zones of sources formation of fresh ground waters" of 16 January 2002).

Uzbekistan's water supply and sanitation (WSS) sector is regulated by the law on drinking water supply and sewage (GoU, 2022c) and faces significant financial challenges as water tariffs were set below cost-recovery levels. Introduced in 2023, increase in prices for supplied water for all regions of Uzbekistan has been increased 10 folds (Daryo.uz, 2022, 2023a, Kun.uz, 2024a, Gazeta.uz, 2023). The tariff approval process in Uzbekistan is elaborate and involves multiple stakeholders. JSC O'zsuvta'minot was tasked with formulating a 2020-2024 WSS sector development concept, encompassing a comprehensive industry analysis, target indicators, investment attractiveness measures, and private sector involvement (WB, 2023). The Joint Stock Company (JSC) O'zsuvta'minot, responsible for setting these tariffs, must navigate a complex and decentralized approval process that involves local councils. JSC O'zsuvta'minot sets the tariff and prepares justifications, which are then communicated to regional offices of the Ministry of Economic Finance and the Committee for Competition Promotion and Consumer Protection. Following this, the proposed tariffs are publicly announced for open discussion for 15 days before being presented to the local council for final approval.

Uzbekistan employs a cross-subsidy method for setting tariffs, where lower rates for households are offset by higher rates for budget organizations and enterprises. Despite this approach, the water tariffs remain among the lowest in the world. This disparity contributes to significant financial sustainability issues, including poor revenue collection rates, which have fallen to 80-82% of their nominal range. Additionally, the sector grapples with non-revenue water issues due to poor asset management, leaks, inadequate water pressure, and water theft (Vinokurov et al., 2022; ADB, 2022)

The recent announcement of new tariffs for drinking water and wastewater services aims to address these inefficiencies. The tariffs for residents in the Tashkent region increased from 950 UZS to 1,700 UZS per cubic meter (Daryo.uz, 2022; Daryo.uz, 2023a; Daryo.uz, 2023b; Kun.uz, 2023; Gazeta.uz, 2023), while tariffs for budget organizations and wholesale consumers have risen from 4,000 UZS to 7,000 UZS per cubic meter. Prices have also been revised for the Kashkadarya, Surkhandarya regions. These adjustments are intended to reduce water wastage and encourage more sustainable water usage practices. The higher tariffs are to support and incentivize conservation and also to provide the necessary funds for infrastructure improvements.

In Uzbekistan, water users pay only for services provided by water user organizations, while the irrigation services provided by state water-management organizations remain free. In contrast, water users in Kazakhstan, Kyrgyzstan, and Tajikistan pay for irrigation services provided by both water-management organizations (WMO) and water consumers association (WCA) (Table. 5). This results in a lower level of financial resources for maintaining and improving irrigation infrastructure in Uzbekistan, compared to neighboring countries. Relative payment (actual/plan, %) and especially unit payment (USD/hectare) for irrigation services provided by WCA are insufficient, which is a major problem for most WCAs. This lack of funds prevents these organizations from employing the necessary number of mirabs (persons who distribute water between users) to ensure high-quality irrigation services. The collected irrigation service fees are not enough to cover operation and maintenance and ensure high-quality management of irrigation and drainage systems. Therefore, water charges are a weak incentive for better water management. Raising tariffs for irrigation services is challenging as it depends on users' willingness and ability to pay, which can lead to social tension if not carefully managed (Vinokurov, 2023; WB, 2024).

Tariffs for irrigation services and the collection of fees are not high enough to encourage water saving at the field level or improve water management at the system and local levels. Both state water management organizations and user organizations are not incentivized to save water, as their funds depend on the amount of delivered water. Users, on the other hand, do not feel compelled to save water because payment for irrigation services is area-wise rather than based on actual water usage.

Table 5. Irrigation water prices in Central Asian countries as of 2019

Country	Service provider	Tarif	
		National currency	USD
Kazakhstan	WMO	16,135 KZT/m^3 (pumped irrigation)	4.15 cent/m^3
		0.295 KZT/m^3 (gravity irrigation)	0.074 cent
	APC	1,600-2,500 KZT/ha	4.1-6.43 USD/ha
Kyrgyzstan	WMO	0.03 KGS/m^3	0,043 cent/m^3
	WUA Union	0.04 KGS/m^3	
	WUA	400-800 KGS/m^3	6-11 USD/ha
Tajikistan	WMO	13.6 TJS/m^3	1.36 USD/m^3
	WUA	40-120 TJS/ha	4-12 USD/ha
Turkmenistan	PFU	3% of farm's yield	
Uzbekistan	WCA	25,000-30,000 UZS/ha	2.6 – 5.2 USD/ha

Sources: Vinokurov et al., 2023; OECD, 2021; Daryo.uz, 2024a

The government's policies towards water tariffs reflect a broader strategy to integrate market principles into the WSS sector. Furthermore, the government is exploring various institutional reforms to improve water management. This includes training programs for local authorities and farmers on water-saving techniques and efficient irrigation practices. Looking at international comparisons, many countries have successfully implemented tiered water pricing structures that balance affordability with cost recovery (Vinokurov et al., 2023). These countries often employ a tiered pricing system, where basic water needs are met at a lower rate, while higher usage is charged at a premium. This approach not only ensures financial sustainability but also promotes water conservation.

Uzbekistan has made significant progress in addressing water management challenges, the current tariff structure and approval process pose substantial barriers to financial sustainability. By adopting international best practices and streamlining the tariff approval process, the government can enhance the efficiency and sustainability of its WSS sector (Daryo.uz, 2023b; Caspian Policy Center, 2020). These efforts, combined with ongoing investments in infrastructure and technology, are crucial for securing the nation's water resources and supporting its long-term development goals.

The most important part of setting water price will be precise monitoring and control system of the water supply down to final consumer. To date, Uzbekistan has installed 11,349 "Smart Water" devices for online water consumption monitoring, improving control efficiency by 10% through the smartwater.uz system. Additionally, 6,657 software programs (divers) have been implemented to enhance land reclamation and monitor groundwater levels online, with the "Melioration" system improving land reclamation assessment accuracy by 20% (Khujaev, 2024).

Currently, 1,722 online water consumption control devices are in place at these stations, supported by a specialized information system. A database and software provide integration with regional electrical networks to monitor energy use, with ongoing data integration into the MWR system. Over the past three years, 65 major water management facilities have been automated and this process is going on finally to establish fully controlled water use management system.

CHAPTER 5. FUTURE WATER RESOURCE MANAGEMENT

5.1. Water demand estimates

Uzbekistan faces significant challenges with inefficient irrigation practices, resulting in high water losses. The significant water used in agriculture is lost through evaporation, seepage, and other inefficiencies. This leads to substantial waste of resources and contributes to water scarcity in the region. Modernizing irrigation infrastructure and adopting advanced irrigation techniques, such as drip and sprinkler systems, are essential to reduce water loss and improve agricultural productivity. The construction of the Afghanistan Qosh-tepa irrigation canal can withdraw up to 25% of the Amu Darya River discharge and will have significant impact to the downstream areas in Uzbekistan and Turkmenistan (Figure 13).

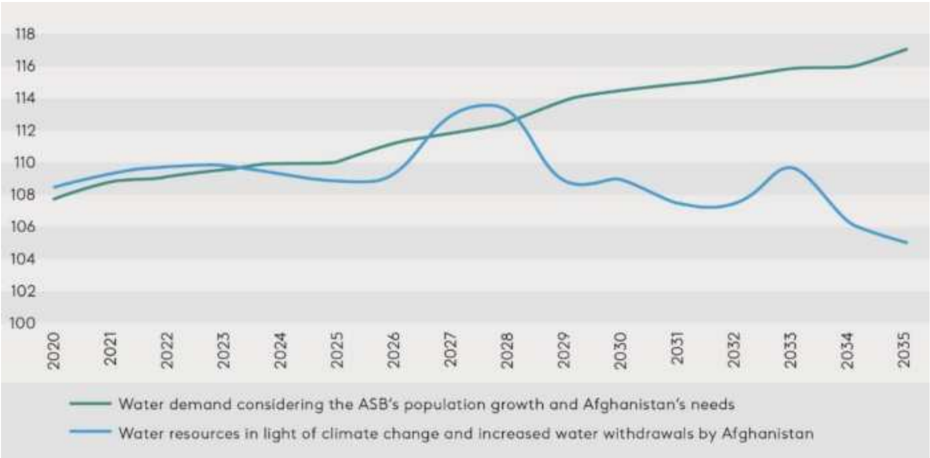


Figure 13. Projected river flow and water withdrawal in the ASB (Aral Sea Basin) by 2035, km³

Source: EDB estimates based on data from ICWS SIC Vinokurov et al., 2024)

Projections show that the amount of water can decrease due to the impact of climate change up to 20% (MWR, 2023), this puts more pressure on water saving policies and water management development in Uzbekistan.

In Uzbekistan, main water development goals and objectives are presented in the concept note to develop water resources management for 2030 (GoU no. 6024: 2020a). Primarily addressing water for the economic sector; improvement of the monitoring and management of water rational use.

The expected water consumption by 2030 data is introduced in Table 6.

Table. 6. Prospective water consumption (demand) in Uzbekistan by 2030

Water consumers	Total water requirement	including by source		
		Surface Water	Underground Water	Return Water
	10^6 m³/year			
Domestic utilities	6,200	2,450	3,750	0
Industry	3,500	1,580	1,920	0
Rural water supply	950	810	140	0
Fisheries	640	460	0	180
Energy	780	780	0	0
Irrigated Agriculture	48,000	46,800	700	500
Total	60,070	52,880	6510	680

Source: MWR, 2022

Irrigated agriculture is crucial for food security, contributing to 66% of the gross agricultural output. However, the sector faces significant challenges, including outdated infrastructure gross losses, and widespread salinization affecting irrigated lands. The inefficiency in the irrigation system leads to significant water loss, with about 37% (MWR, 2023) of water lost due to filtration and evaporation. This inefficiency not only wastes water but also reduces the overall productivity of the agricultural sector, exacerbating food security issues in the region.

Future water demand in agriculture will continue to be high, requiring substantial investments in modernizing irrigation systems. Adopting advanced irrigation technologies, such as drip and sprinkler systems, can optimize water use and reduce losses. The government is planning to increase application of the water saving technologies to 2 million ha. and drip irrigation application to 500 thousand hectare (Figure 14). These technologies deliver water directly to the plant roots, minimizing evaporation and runoff. Additionally, the introduction of precision farming techniques, including laser land leveling, can enhance water distribution uniformity across fields. Starting from year 2024, laser leveling is also included in the program of water saving credit subsidies for farmers. Although, many reports point out that without effective water tariffs, it will be hard to encourage water conservation and ensure sustainable agricultural practices (ADB, 2022; ADB, 2023; Vinokurov et al., 2023; WB, 2022). By charging for water usage, farmers are incentivized to adopt more efficient practices and technologies, ultimately leading to a more sustainable use of water resources.

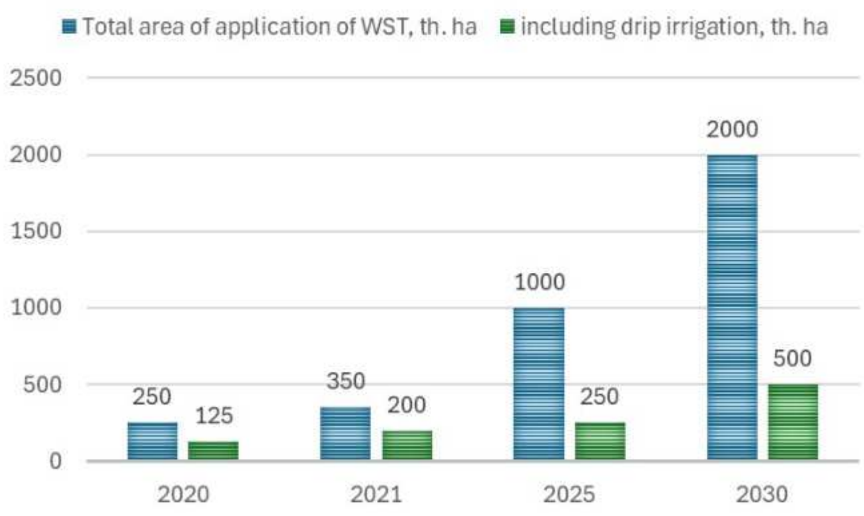


Figure 14. Goals application of water saving technologies (WST)

Source: MWR, 2023

Another important issue is anti-filtration lining of the irrigation canals and investments into the infrastructure for water supply, most of the infrastructure for water distribution were constructed during the soviet time, and have already been in operation for more than 30 years. Currently, only 36% of the inter-farm canals are protected from infiltration losses, this figure is expected to rise to 46% by 2030 (MWR, 2023). As well as improving efficiency of the pumping stations, which are installed all over Uzbekistan for water distribution. These water distribution systems and high-volume water transfer systems such as Amu-Bukhara canal and Amu-Karshi canal are morally and physically worn out. The service life of more than 60% of pumping equipment has already expired, with usage rate of over 30 years. It will also place a burden on the energy system requiring more power while increasing cost of produced agricultural products. By 2030, energy consumption by the pumping station should be reduced by 25% from 8 x 10^6 to 6 x 10^6 kw - hour. Goals for the anti-filtration has been defined and currently under implementation (Figure 15). Increasing water saving and water productivity require significant investment, especially to decrease the percentage of earthen canals, but it will improve irrigation network efficiency by 10% only (MWR, 2023).

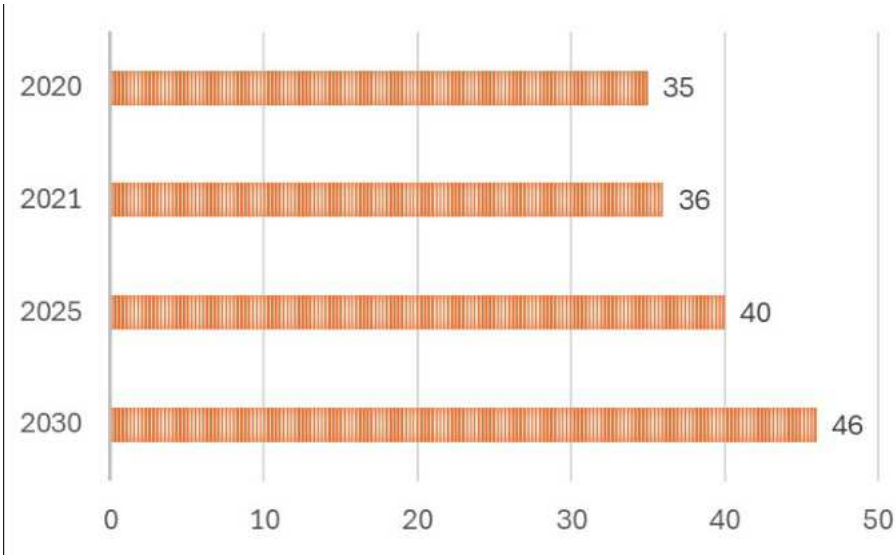


Figure 15. Goal of the increasing anti-filtration concrete canal

Source: MWR, 2023

Municipal water demand is increasing due to population growth and urbanization. Future projections indicate that water shortages will worsen as the population is expected to reach nearly 40 million by 2030 (WB, 2022; MWR 2023). Uzbekistan's water supply faces significant challenges with increasing demand and substantial losses. The water loss rate is high, with about 32% of the total drinking water produced lost due to inefficiencies in the distribution system (Vinokurov et al., 2024). Addressing these issues requires substantial investments in improving water infrastructure, including the replacement of old pipes, installation of leak detection systems, and upgrading of water treatment facilities. Reducing losses through better management practices and advanced technologies is crucial to ensuring a reliable and safe water supply. Upgrading sanitation facilities is equally important to prevent contamination of water sources and protect public health. Integrated water and sanitation management plans, incorporating both infrastructure improvements and effective policies, are essential to meet the needs of growing urban populations.

As Central Asian continues to industrialize, an industrial water demand is also projected to grow significantly. Industries rely heavily on water for various processes, including cooling, cleaning, and production. By 2030, industrial water demand in the region is expected to increase by 75% to 3.5 billion m^3/year (Vinokurov et al., 2023). This growth will put additional pressure on already stressed water resources, necessitating the adoption of efficient water management practices and recycling technologies to reduce consumption. Efficient water management in industries involves optimizing water use in production processes, implementing water-saving technologies, and treating and reusing wastewater.

Hydropower is another significant user of water, although less impactful in Uzbekistan, it is still crucial for energy production. The operation of hydropower plants affects river flow regimes and water availability. Although Uzbekistan doesn't have large hydropower dams in its territory, neighboring countries (Kyrgyzstan and Tajikistan) hydropower operations will have significant contribution. As climate change leads to altered precipitation patterns and reduced glacial melt, the productivity of hydropower plants is projected to decline significantly by 2050. This decline poses could be significant in short and long run, due to adaptation of the upper stream countries to a new regime of the river flow and changes in dam operation.

5.2. Adaptation measures

Balancing water use in agricultural, municipal, and industrial needs will be challenging, especially during dry periods. Integrated water resource management and policies, addressing transboundary water sharing between countries especially with Afghanistan are needed to ensure compromises of the water availability for all countries. Investing in modernizing infrastructure and dam development in the upper stream countries, as Uzbekistan is doing in Rogun Dam and Kambar-ata II development, may improve transboundary cooperation (Umirbekov et al., 2023), at the same time, Uzbekistan should continue investments into efficiency and reduce water losses (WB, 2019a; WB 2019b). Furthermore, exploring alternative renewable energy sources, such as solar and wind, can diversify the energy mix and reduce reliance on hydropower, alleviating some of the pressure on water resources (WB, 2024; Vinokurov et al., 2022).

To address the challenges of water demand and ensure sustainable management of water resources there are several key measures. Modernizing irrigation infrastructure is critical to reduce water losses and improve water productivity and efficiency. This includes rehabilitating and upgrading existing irrigation systems, as well as introducing advanced technologies like drip and sprinkler irrigation. Promoting water-saving technologies, such as precision farming, laser leveling and smart irrigation systems, can significantly enhance water use efficiency. Introduction of just one of water saving technologies can increase yield and decrease fuel and fertilizers application by 20-40% (Kurbonmuratov, 2024). These technologies enable better control over water application, reducing waste and ensuring that crops receive the right amount of water at the right time.

Economic and policy measures, such as effective water and energy tariffs and public-private partnerships, are crucial for funding infrastructure improvements. Implementing water tariffs can provide financial resources for maintenance and development of water infrastructure, while public-private partnerships can mobilize additional investment and expertise. Enhancing water conservation practices through education and awareness campaigns is vital to encourage responsible water use. Adaptation measures must also include climate change mitigation and resilience building, such as improving water storage capacity, protecting watersheds, and developing drought-resistant crop varieties. Integrating these measures into national and regional policies will help ensure sustainable water management and resilience to future challenges.

In 2024, Uzbekistan plans to concrete 5,000 km of irrigation networks, including 1,500 km of main and inter-farm canals and 3,500 km of intra-farm networks. To date, 518.2 km of canals have been reconstructed, with 351.7 km concreted, bringing the total length of restored irrigation networks to 11,000 km. (Khujaev, 2024).

Water-saving technologies have been implemented on 1.3 million ha. including 478,000 ha. with drip irrigation, 55000 ha. with sprinkler irrigation, 29,000 ha. with discrete irrigation, and over 700,000 ha. leveled using laser technology. In 2024, modern irrigation technologies will be adopted in 500,000 ha. with a goal of reaching 4.3 million ha. by 2030. Additionally, 55 local enterprises have been established to produce water-saving devices and parts. The country aims to save around 8×10^6 m^3/year of water through these measures, addressing the challenges of global climate change and increasing water demand due to population and industrial growth.

CHAPTER 6. CONCLUSION AND RECOMMENDATIONS

6.1. Transboundary water resources and emerging risks

Transboundary water management and water transportation and distribution network is an important issue for Uzbekistan, and the country is addressing these issues by increasing its investment in the water saving techniques and improvement of the infrastructure. Considering the Qosh-tepa Canal construction and addition of Afghanistan into the water sharing of the Aral Sea, requested to develop interactions among all countries on the Amu Darya River, especially for the delta area of the Aral Sea. At the same time, focusing on agriculture, industry and municipal water distribution, it is important to point out environmental and ecological concerns that persist in Uzbekistan. This inconsistency necessitates improved cooperation and management of shared water resources to ensure equitable access and minimize risks of disagreements.

Uzbekistan emphasizes bilateral relations alongside regional and international cooperation to manage water issues in Central Asia, fostering a unique “water diplomacy" with neighboring countries. Effective transboundary water sharing policies, especially with Afghanistan, are essential. Modernizing infrastructure and investing in upstream dam projects, like Uzbekistan's involvement in Rogun and Kambar-ata II, can enhance cooperation. Another example is the November 2017 agreement between Uzbekistan and Kyrgyzstan on the joint use of the Kasan-Sai Reservoir. This agreement covers the safety, operation, and maintenance of water facilities, ensuring regulated water supply. Uzbekistan agreed to participate in maintaining the reservoirs and share the financial costs associated with the water received under the agreement. These steps will ensure water availability on mutual trust and cooperation between the countries. Simultaneously, Uzbekistan should continue improving efficiency and reducing water losses.

Another example is the Joint Uzbek-Turkmen Intergovernmental Commission on Water Management meeting in Turkmenabad, Turkmenistan on April 30, 2024. As parties agreed to accelerate the registration of Uzbek water management facilities located in Turkmenistan and to proceed with a project to construct an anti-filtration wall at the Sultan Sanjar Dam within the Tuyamuyun hydroelectric complex. (Khujaev, 2024)

To address these challenges, Uzbekistan should engage in regional cooperation and dialogue with upstream countries to develop mutually beneficial water management strategies. Collaborative efforts should focus on optimizing water usage, improving water infrastructure, and implementing joint projects that enhance water security and sustainability for all parties involved. Strengthening transboundary water resource management will contribute to regional stability and sustainable development (FAO, 2012; OECD, 2020; Umirbekov et al., 2023).

6.2. Climate change and environmental impacts

The consensus among researchers is that climate change will pose significant challenges to water resources management in Central Asia. In the short term, accelerated glacier melting may temporarily alleviate water stress by increasing water availability (Shukla et al., 2021). However, this situation is likely to be short-lived. As temperatures continue to rise, evapotranspiration rates will increase, leading to higher water demands for agriculture and other uses. According to forecast of MWR river flow in the Amu Darya and the Syr Darya, these rivers will decrease by 15% and 5% by 2050, respectively. Concurrently, land degradation due to increased salinity and the necessity for soil leaching will exacerbate water scarcity.

These processes will particularly impact downstream countries, including Uzbekistan. Further, the increased demand for water, combined with the diminishing supply from melting glaciers, will strain existing water management systems. Additionally, higher temperatures and altered precipitation patterns will further complicate the balance between water supply and demand. This scenario pushes for urgent need in adaptive water management strategies for both immediate and long-term impacts of climate change on water resources in the region.

The Amu Darya, which historically flowed to the Aral Sea, now rarely supplies water to it, as most of the water is diverted for irrigation between Turkmenistan and Uzbekistan. Water diversion for irrigation and other human activities has disrupted the natural hydrological balance of the Aral Sea basin, causing various environmental, social, and ecological impacts in the region. This has not only impacted the Aral Sea itself but also the surrounding environments such as wetlands and lakes within the basins. According to the (IFAS, 2024) and Dukhovny (2021), in recent decades, wetlands and lakes in downstream areas have received only 30% of the average water flow. The Qosh-Tepa Canal construction is likely to change previous water allocations and accelerate desertification in the downstream area that is expanding from the bottom of the Aral Sea. Consequently, the canal construction will have significant, if not severe, impacts on the region's politics and economics.

Increased temperatures and further impacts of the salinization to the land degradation will have to be addressed in the shortest terms. It will require several changes to the agricultural irrigation practices, inclusion of the water saving techniques and reduction in water consumption with integration of the drought and salt tolerant plants. Implementing policies that promote water efficiency and the treatment and reuse of wastewater, including crops that can withstand soil salinity such as halophytes (Toderich et al., 2024) can help mitigate the impact on overall water demand.

The Aral Sea region, severely affected by ecological imbalance, remains a priority. Recent efforts have led to the planting of saxaul and other desert plants on 1.7 million ha. of the dried Aral Sea former bed, increasing green cover by 2 million ha. By 2026, an additional 400,000 ha. will be greened, contributing to the recovery from this environmental disaster. Creating the green belt on the bottom of the Aral Sea, a protective forest plantation to control sand and salts movement from the former bed of the Aral Sea. However, not only deserts should be addressed, but it is also important to control water reach for the wetlands in the downstream areas, which are living habitat for fauna in the area.

Green belts are required not only in desert but will have to be grown near the cities, the parks, and tree plantings along major roads and railways based on natural conditions to address urbanization and land degradation. The nationwide "Yashil Makon" project, launched in 2021, has already seen significant progress, with 10 million trees and shrubs planted in spring 2023 alone. By 2026, the project aims to plant 1 billion trees and shrubs to mitigate environmental pressures and climate effects.

6.3. Water use and infrastructure

The current water allocation approach in Uzbekistan relies on outdated crop water use norms, leading to overestimation of water requirements and low water productivity. Modernizing irrigation systems, including pumps and canals, is crucial to improving efficiency and reducing water losses. With most irrigation pumps exceeding their standard life and requiring modernization, significant investments are needed to upgrade the infrastructure. Balancing water use across agriculture, municipal, and industrial sectors is challenging, particularly during dry periods.

Although, the level of water-saving technologies should increase as with current Uzbekistan's large scale agriculture sector, there are several constraints, including low productivity and economic returns. Climate change projections indicate a significant decrease in water supply and an increase in water demand, exacerbating the existing water deficit. The country's reliance on outdated irrigation systems and inefficient water management practices further compounds these challenges, leading to substantial economic losses and reduced agricultural productivity.

A significant portion of Uzbekistan's irrigated land is affected by salinity, leading to waterlogging, soil degradation, and reduced agricultural productivity. The annual cost of these issues is estimated at 4% of GDP (OECD, 2022; Toderich at al., 2024), highlighting the urgent need for effective mitigation measures. Improved surface and subsurface drainage systems are essential to address these challenges and enhance land productivity. Investing in advanced technologies for monitoring soil salinity and implementing effective drainage systems, in addition to integration of the framework of drought and salt tolerant crops will help mitigate the impacts of salinity and waterlogging.

6.4. Water saving technologies integration

There are many questions about the legal and regulatory conditions to the shift in smart agriculture and improving water productivity. Significant improvements are needed in the legal and regulatory environment to encourage public and private investment in climate-smart agricultural technologies. The passing of the Water Code into law will address some of the legal questions on this subject. This includes efforts in land and resource conservation and investments in climate change resilience, especially in critically vulnerable areas like the Aral seabed.

The Presidential Decree (GoU, 2024) outlines key directions for improving water resource efficiency in 2023, including strict distribution of water among consumers, enhanced state support for water-saving technologies, and the adoption of modern information and communication technologies in water management. Starting January 1, 2025, Uzbekistan will implement the "Water Accounting" information system nationwide (Uzdaily.uz, 2023). This system will enable electronic completion and approval of monthly agreements between water supply organizations and water consumers using electronic digital signatures.

The adoption of water-saving technologies has yielded significant benefits in Uzbekistan. The area utilizing these technologies increased from 28,000 ha. in 2018 to more than 800,000 ha. today (MWR, 2023). These advancements have resulted in substantial water savings, with drip, sprinkler, and laser leveling methods proving highly effective. The positive impact of water-saving technologies is evident in increased crop yields and reduced resource consumption. Encouraging the widespread adoption of these technologies among farmers will further enhance agricultural productivity and sustainability.

6.5. Addressing irrigation efficiency

To enhance water management in Uzbekistan, public investments should prioritize the expansion of water controlling and monitoring systems and the modernization of irrigation infrastructure. These measures are essential for improving water efficiency and increasing climate resilience. By implementing these initiatives, Uzbekistan can address the annual loss of 5-6x10^9 m^3 of water caused by outdated irrigation methods and better manage its water resources. Aging infrastructure, lack of maintenance, and inadequate management practices contribute to these losses.

Integrating digital solutions in the water sector will improve water allocation and accounting, contributing to better management of water resources. The use of remote sensing technologies for monitoring water resources, soil salinity and irrigation efficiency will provide reliable data for informed decision-making. By embracing digital agriculture, Uzbekistan can achieve sustainable and efficient agricultural practices. Digital water distribution monitoring and control offer significant potential to improve water use efficiency and increase agricultural productivity by water distribution control.

Improving water management practices and modernizing irrigation systems are essential to address these constraints. Upgrading the existing infrastructure, enhancing field efficiency, and adopting modern technologies will help increase water productivity and reduce losses. Additionally, improving the legal and regulatory framework for water management will support sustainable agricultural practices and ensure the long-term viability of the sector.

At the same time, a reasonable tariff system for water supply services should be implemented, to encourage responsible water use and support the modernization of irrigation infrastructure. Uzbekistan can attract the necessary investments to support sustainable water management and agricultural practices through public interest and investment into the sector. Planned introduction of water control and use from 2025 will address these issues; however, application and management still raise questions on efficiency.

6.6. Future strategies and development

The government's *Water Sector Development Concept for 2020–2030* outlines a comprehensive approach to modernizing water management from main canals to on-farm levels. This includes capacity development and a new system of state support for water-saving irrigation technologies. The strategy's goal is to meet the growing needs for water in the face of increasing scarcity and climate change, ensuring efficient and sustainable water use across various sectors. It also addresses set SDG goals in reduction of CO2 emissions to 30%, and increase in the use of green energy in the region which will help in providing green energy for water saving technologies as well as irrigation through pumping system. Energy conservation is crucial, as 60% of irrigated land relies on pumping stations and irrigation wells. The concept also highlights rates of water efficiency targets, reduction in water use, application and increase in water saving technology. The goals include improving water use efficiency in Uzbekistan by 25%, expanding water-saving irrigation technologies to cover 2 million ha., with 600.000 ha. utilizing drip irrigation. It will also help to establish domestic production capacity of drip irrigation pipes and other required equipment. All drinking water consumers will have meters installed, and improvements in drinking water quality, accessibility, and the performance of water supply and sewerage enterprises will be implemented by 2030. It also includes large-scale initiatives for developing forestry, nurseries, irrigation systems, and water wells. The annual Investment Program for Targeted Planting will support these efforts.

As the urban population continues to grow, the pressure on existing water supply systems will intensify, leading to more frequent shortages and disruptions. Enhancing the legal environment to support private sector involvement in irrigation and investments in digital agriculture technologies will further improve water management and conservation efforts, and this will be addressed in the Water Code law.

It is also important to point out significant efforts by the Uzbek government's strategy to diversify away from cotton and wheat production. It will increase water productivity and address farmers' economic gains and enforce implementation of intensive agriculture on the bigger scale. The government's climate change adaptation measures, outlined in its nationally determined contributions to the Paris Agreement, aim to improve climate resilience, mitigate desertification, and enhance water and irrigation management. Additionally, enhancing the capacity of water management organizations and providing continuous education and training for staff will improve the overall management of water resources and support sustainable agricultural practices.

The structure of the institutional and legal framework of the water and agriculture control requires stipulating the roles and responsibilities of the water management operations and integration of these systems. Another important point is advanced education, research, and production to enhance the capacity of water sector specialists.

Thus, in upcoming years, key policy recommendations for improving the water sector in Uzbekistan can be summarized as below:

Municipal water use and access- i) invest in modernizing and maintaining water supply infrastructure to reduce leaks and water quality; ii)implement water-saving measures, encourage water conservation practices among urban residents and businesses, through incentives and public awareness campaigns; iii) expand access to safe drinking water by focus on improving water access in underserved and rural areas for ensuring equitable access to safe drinking water for public health and well-being; iv) enhance wastewater treatment and reuse by investing in advanced wastewater treatment technologies and promote the reuse of treated wastewater;

Water Protection - develop and enforce stricter regulations for water pollution control and land use to protect water quality and prevent degradation of water resources; vi) implement watershed management plans to protect and restore natural water systems; involve communities in water protection initiatives and decision-making processes;

Agriculture Water Management- transferring to water-efficient technologies-adoption of drip irrigation and others*;*

Improvement of Soil Management Practices -implementing soil conservation techniques to increase soil water retention and reduce runoff;

Support Crop Selection and Rotation- Promote the use of drought-resistant crop varieties and diversified crop rotations for better soil fertility;

Develop Integrated Water Management Plans- Implement comprehensive water management plans that integrate agricultural needs with overall water availability and balance water use across sectors;

Transboundary Cooperation - Engage in and support regional agreements and treaties that address transboundary water management, by developing joint water management projects platform for sharing water data, promoting regular dialogue sessions between basin countries, and to address emerging issues and coordinate actions.

References

Aizen, V.B., Aizen, E.M., Melack, J.M., Dozier, J. (1997). Climate and hydrologic changes in the Tien Shan. *Central Asia Journal of Climate*, 10. p. 1393-1404

ADB (2018). Report and Recommendation of the President to the Board of Directors: Sector assessment (summary): agriculture, natural resources, and rural development. Horticulture Value Chain Development (RRP UZB 47305) https://www.adb.org/sites/default/files/linked-documents/47305-002-ssa.pdf

ADB (2022). Climate Adaptive Water Resources Management in the Aral Sea Basin Sector Project: Report and Recommendation of the President Reports and Recommendations of the President, August 2022. Sector Assessment (Summary): Agriculture, Natural Resources, and Rural Development. https://www.adb.org/sites/default/files/linked-documents/53120-001-ssa.pdf

Asian Development Bank, (2023). Uzbekistan: Horticulture Value Chain Development Project report. https://www.adb.org/sites/default/files/linked-documents/47305-002-ssa.pdf

Bobojonov, I., Berg, E., Franz-Vasdeki, J., Martius, C., & Lamers, J. P. (2016). Income and irrigation water use efficiency under climate change: An application of spatial stochastic crop and water allocation model to Western Uzbekistan. Climate Risk Management, 13, 19-30.

Bolch, T., (2007). Climate change and glacier retreat in northern Tien Shan (Kazakhstan/Kyrgyzstan) using remote sensing data. Global and Planetary Change, 56(1–2), 1–12. https://doi.org/10.1016/j.gloplacha.2006.07.009

Buchhorn, M., Lesiv, M., Tsendbazar, N.E., Herold, M., Bertels, L., Smets, B. (2020). Copernicus Global Land Cover Layers—Collection 2. Remote Sens. 2020, 12, 1044.

Caspian Policy Center (CPC), (2020). The Vital Resource: Water Management in Central Asia.

https://api.caspianpolicy.org/media/uploads/2020/11/The-Vital-Resource-Water-Management-in-Central-Asia-01.pdf

Chen, Y., Li, W., Deng, H., Fang, G., & Li, Z. (2016). Changes in Central Asia's water tower: past, present and future. Scientific Reports, 6(1). https://doi.org/10.1038/srep35458

Dankova, R., Burton, M., Salman, M., Clark, AK. & Pek, E. (2022). Modernizing irrigation in Central Asia: concept and approaches. Directions in Investment, No. 6. Rome, FAO and The World Bank. https://openknowledge.fao.org/server/api/core/bitstreams/3d94fe50-105e-4e2b-801e-5ceb6068096e/content

Daryo.uz (2022, October 11). Water supply in Uzbek villages improves. https://daryo.uz/en/2022/10/11/water-supply-in-uzbek-villages-improve

Daryo.uz (2023a, July 28). Prices of water increase to manage water scarcity in Uzbekistan. https://daryo.uz/en/2023/07/28/prices-of-water-increase-to-pervent-water-scrancity-in-uzbekistan

Daryo.uz (2023b, October 21). Shavkat Mirziyoyev calls for urgent action on inefficient water use in agriculture. https://daryo.uz/en/2023/10/21/shavkat-mirziyoyev-calls-for-urgent-action-on-inefficient-water-use-in-agriculture

Daryo.uz (2023c, November 21). Starting next year, a ban on the use of groundwater without meters will be introduced in the Republic of Uzbekistan (Со следующего года в РУз вводится запрет на использование подземных вод без счётчиков) https://daryo.uz/ru/ 2023/11/21/co-sleduusego-goda-v-ruz-vvoditsa-zapret-podzemnymi-vodami-bez-scetcika

Daryo.uz (2024a, February 3). Tajikistan raises water tariffs for crop irrigation by 150%. https://daryo.uz/en/2024/02/03/tajikistan-raises-water-tariffs-for-crop-irrigation-by-150

Daryo.uz (2024b, March 15). Uzbekistan launches project for water supply and sanitation amid climate change challenges. https://daryo.uz/en/2024/03/15/uzbekistan-launches-project-for-water-supply-and-sanitation-amid-climate-change-challenges

Daryo.uz (2024c, July 30). Uzbekistan plans to adopt Water Code to enhance water management efficiency. https://daryo.uz/en/2024/07/30/uzbekistan-plans-to-adopt-water-code-to-enhance-water-management-efficiency

Dukhovny, V., Stulina, G., and Kenjabaev, Sh., (2021). Monitoring of the drained bottom of the Aral Sea. https://www.undp.org/uzbekistan/publications/monitoring-drained-bottom-aral-sea

FAO (2012). AQUASTAT. Transboundary River Basin Overview – Aral Sea. Food and Agriculture Organization of the United Nations (FAO). Rome, Italy

FAO (2024). FAOLEX database. Agreement between the Republic of Kazakhstan, the Republic of Kyrgyzstan, the Republic of Uzbekistan, the Republic of Tajikistan and Turkmenistan on cooperation in the field of joint water resources management and conservation of interstate sources. www.fao.org/faolex/results/details/en/c/LEX-FAOC054529/

FAO (2024). AQUASTAT - FAO's Global Information System on Water and Agriculture. https://www.fao.org/aquastat/en/

Farinotti, D., Longuevergne, L., Moholdt, G., Duethmann, D., Mölg, T., Bolch, T., Vorogushyn, S., & Güntner, A. (2015). Substantial glacier mass loss in the Tien Shan over the past 50 years. Nature Geoscience, 8(9), 716–722. https://doi.org/10.1038/ngeo2513

Gazeta.uz (2023, November 28). Tashkent increases cold water and sewerage bills. https://www.gazeta.uz/en/2023/11/25/tashkent-increases-cold-water-and-sewerage-bills/

GoU(1993). On Water and water use (Suv va suvdan foydalanish to'g'risida). Law of the Republic of Uzbekistan. 837-XII from 06.05.1993. https://lex.uz/ru/docs/-12328

GoU (2017). On measures to further streamline activities in the field of groundwater use. (Yer osti suvlaridan foydalanish sohasidagi faoliyatni yanada tartibga solish chora-tadbirlari to'g'risida). Resolution of the Cabinet of Ministers of the Republic of Uzbekistan no. 430. from 06.27.2018. https://lex.uz/ru/docs/-3251292

GoU (2018a). On measures to increase the efficiency of water use (Suv resurslaridan foydalanish samaradorligini oshirish chora-tadbirlari toʻgʻrisida). Decree President of the Republic of Uzbekistan no. from 02.07.2018. https://lex.uz/ru/docs/-3804060

GoU (2018b). On measures to allocate subsidies from the state budget of the Republic of Uzbekistan to cover the cost of electricity consumed by farm pumping units and irrigation wells. (Fermer xo'jaliklarining nasos agregatlari va sug'orish quduqlari iste'mol qiladigan elektr energiyasi qiymatini qoplash uchun O'zbekiston Respublikasi Davlat budjetidan subsidiyalar ajratish chora-tadbirlari to'g'risida). Resolution of the Cabinet of Ministers of the Republic of Uzbekistan no. 320. from 05.03.2018. https://lex.uz/ru/docs/-3718546

GoU (2018c). On the approval of some administrative regulations for the provision of the state services in the field of nature use. (Tabiatdan foydalanish sohasida davlat xizmatlari koʻrsatishning ayrim ma'muriy reglamentlarini tasdiqlash toʻgʻrisida). Resolution of the Cabinet of Ministers of the Republic of Uzbekistan no. 255. from 31.03.2018. https://lex.uz/ru/docs/-3646578

GoU,2019a. On measures for the efficient use of land and water resources in agriculture. (Qishloq xoʻjaligida yer va suv resurslaridan samarali foydalanish chora-tadbirlari toʻgʻrisida) Decree of the President of the Republic of Uzbekistan no. PF-5742 from 17.06.2019 https://lex.uz/ru/docs/4378524

GoU(2019b). On Practical measures to ensure rational use of underground water in some regions. Ayrim hududlarda yer osti suvlaridan oqilona foydalanishni ta'minlash bo'yicha amaliy chora-tadbirlari to'g'risida. Resolution of the Cabinet of Ministers of the Republic of Uzbekistan no. 855 from 09.10.2019. https://lex.uz/ru/docs/-4546611

GoU (2020a). On approval of the concept of development of the water industry of the Republic of Uzbekistan for 2020-2030 (O'zbekiston Respublikasi suv xo'jaligini rivojlantirishning 2020–2030-yillarga mo'ljallangan konsepsiyasini tasdiqlash to'g'risida). Decree of the President of the Republic of Uzbekistan, no. PF-6024 from 10.07.2020. https://lex.uz/ru/docs/-4892953

GoU(2020b). On measures to accelerate the introduction of water-saving technologies in agriculture (Qishloq xoʻjaligida suvni tejaydigan texnologiyalarni joriy etishni yanada jadal tashkil etish chora-tadbirlari toʻgʻrisida). Decree of the President of the Republic of Uzbekistan, no. PQ-4919 from 11.12.2020. https://lex.uz/uz/docs/-5157168

GoU, 2022a. On additional measures for the protection and regulation of rational use of underground water resources (Yer osti suv resurslarini muhofaza qilish va ulardan oqilona foydalanishni tartibga solish boʻyicha qoʻshimcha chora-tadbirlar toʻgʻrisida). Decree of the President of the Republic of Uzbekistan, no. PP-439 from 7.12.2022. https://lex.uz/ru/docs /6311247

GoU(2022b). On additional measures for the protection and regulation of rational use of underground water resources (Tadbirkorlik muhitini yaxshilash va xususiy sektorni rivojlantirish orqali barqaror iqtisodiy oʻsish uchun shart-sharoitlar yaratish borasidagi navbatdagi islohotlar toʻgʻrisida). Decree of the President of the Republic of Uzbekistan, no. PF-101 from 08.04.2022. https://lex.uz/uz/docs/-5947775

GoU (2022c). On drinking water supply and sewage disposal (Ichimlik suvi ta'minoti va oqova suvlarni chiqarib yuborish to'g'risida). Law of the Republic of Uzbekistan, no. O'RQ-784 from 22.07.2022. https://lex.uz/uz/docs/-6126864

GoU(2023). On the introduction of amendments and additions to some legal documents of the Republic of Uzbekistan in connection with the adoption of the main directions of the tax and budget policy for 2024 (On amendments and additions to some legal documents of the Republic of Uzbekistan in connection with the adoption of the main directions of the tax and budget policy for 2024). Law of the Republic of Uzbekistan, no. OPQ-891 from 28.12.2023. https://lex.uz/docs/-6718864

GoU (2024). On measures to improve the water resource management system at the lower level and increase the efficiency of water resources use (Quyi bo'g'inda suv resurslarini boshqarish tizimini takomillashtirish hamda suv resurslaridan foydalanish samaradorligini oshirish chora-tadbirlari to'g'risida). Decree of the President of the Republic of Uzbekistan, no. PQ-5 from 05.01.2024. https://lex.uz/docs/-6734972

Gummadi, S., Samineni, S., & Lopez-Lavalle, L. a. B. (2024). Assessing High-Resolution Precipitation Extremes in Central Asia: Evaluation and future projections. *Research Square (Research Square)*. https://doi.org/10.21203/rs.3.rs-4447542/v1

Hamidov, A., Thiel, A., & Zikos, D. (2015). Institutional design in transformation: A comparative study of local irrigation governance in Uzbekistan. *Environmental Science & Policy*, *53*, 175–191. https://doi.org/10.1016/j.envsci.2015.06.012

Hamidov, A., Kasymov, U., Salokhiddinov, A., & Khamidov, M. (2020). How can intentionality and path dependence explain change in Water-Management institutions in Uzbekistan? *International Journal of the Commons*, *14*(1), 16-29. https://doi.org/10.5334/ijc.947

Hu, Z., Li, Q., Chen, X., Teng, Z., Chen, C., Yin, G., & Zhang, Y. (2015). Climate changes in temperature and precipitation extremes in an alpine grassland of Central Asia. *Theoretical and Applied Climatology*, *126*(3–4), 519–531. https://doi.org/10.1007/s00704-015-1568-x

Hu, Z., Zhang, C., Hu, Q., & Tian, H. (2014). Temperature Changes in Central Asia from 1979 to 2011 Based on Multiple Datasets*. *Journal of Climate*, *27*(3), 1143–1167. https://doi.org/10.1175/jcli-d-13-00064.1

ICWC (2024). http://icwc-aral.uz/index_e.htm

IFAS (2024). Agency for implementation in the Aral Sea basin https://aral.uz/en/

Jiang, J., Zhou, T., Chen, X., & Zhang, L. (2020). Future changes in precipitation over Central Asia based on CMIP6 projections. Environmental Research Letters, 15(5), 054009. https://doi.org/10.1088/1748-9326/ab7d03

Joint Monitoring Program (JMP) (2019): Progress on household drinking water, sanitation and hygiene 2000-2017. Special focus on inequalities. New York: United Nations Children's Fund (UNICEF) and World Health Organization, 2019.

Kariyeva, J., & Van Leeuwen, W. (2011). Environmental drivers of NDVI-Based Vegetation Phenology in Central Asia. *Remote Sensing*, *3*(2), 203–246. https://doi.org/10.3390/rs3020203

Khamraev, Sh. (ed.), Mukhamednazarov, L., Sokolov, V., Gayfulin, E., eds. (2020). Irrigation and drainage in republic of Uzbekistan history and modern state. Ministry of Water Resources of the Republic of Uzbekistan, 2020. National Committee on Irrigation and Drainage (UzNCID). Tashkent 2020. https://icid-ciid.org/icid_data_web/UzNCID_book_web_en.pdf

Kholmatjanov, B. M., Petrov, Y. V., Khujanazarov, T., Sulaymonova, N. N., Abdikulov, F. I., & Tanaka, K. (2020). Analysis of Temperature Change in Uzbekistan and the Regional Atmospheric Circulation of Middle Asia during 1961–2016. *Climate*, *8*(9), 101. https://doi.org/10.3390/cli8090101

Khujaev, K. (2024, May 27). Uzbekistan takes bold steps to address water scarcity - Embassy of Uzbekistan in the united states. embassy of uzbekistan in the united states. https://uzbekistan.org/uzbekistan-takes-bold-steps-to-address-water-scarcity/4551/

Khujanazarov, T., Touge, Y., Tanaka, K. (2024). Balancing Development and Water Management in the Amu Darya: Lessons from Afghanistan's New Irrigation Canal. JSHWR Annual Meeting, 2024.

Kijne, J. 1., International Programme for Technology and Research in Irrigation and Drainage, R. e. 4., & FAO, R. L. a. W. D. D. e. (2005). Aral Sea Basin Initiative. Towards a strategy for sustainable irrigated agriculture with feasible investment in drainage. Synthesis report. (Rome) (Italy) IPTRID/FAO.

Knorr, H., Theesfeld, I., & Soliev, S. (2021). License to drill: Typology of groundwater use regulations in agriculture of Uzbekistan. International Journal of Water Resources Development, 38(5), 815–835. https://doi.org/10.1080/07900627.2021.1924633

Komilov, O. K. (2024). The History Of The Irrigation System In Uzbekistan. Texas Journal of Multidisciplinary Studies, 29, 20-26. https://doi.org/10.62480/tjms.2024. vol29.5031.pp20-26

Kun.uz (2023, July 26). *Price of drinking water to increase in regions of Uzbekistan*. Kun.uz. https://kun.uz/en/news/2023/07/26/price-of-drinking-water-to-increase-in-regions-of-uzbekistan

Kun,uz (2024a, February 5). Tashkent region to see rise in water supply and sewerage tariffs. https://kun.uz/en/news/2024/02/05/tashkent-region-to-see-rise-in-water-supply-and-sewerage-tariffs

Kun.uz. (2024b, July 30). Proposed Water Code in Uzbekistan to boost resource management and efficiency. Kun.uz. https://kun.uz/en/news/2024/07/30/proposed-water-code-in-uzbekistan-to-boost-resource-management-and-efficiency

Kurbonmuratov, A. (2024, February 9). Uzbekistan seeks to introduce new technologies for irrigation of agricultural lands - CABAR.asia. CABAR.asia. https://cabar.asia/en/uzbekistan-seeks-to-introduce-new-technologies-for-irrigation-of-agricultural-lands

Lehner, B., Verdin, K., & Jarvis, A. (2008). New global hydrography derived from spaceborne elevation data. Eos, 89(10), 93–94. https://doi.org/10.1029/2008eo100001

Lioubimtseva, E., & Henebry, G. (2009). Climate and environmental change in arid Central Asia: Impacts, vulnerability, and adaptations. *Journal of Arid* Environments, 73(11), 963–977 https://doi.org/10.1016/j.jaridenv.2009.04.022

Liutin A.(2023). Irrigation innovation: Navigating challenges in Uzbekistan's water–energy–food–environment nexus - CGIAR. https://www.cgiar.org/news-events/news/irrigation-innovation-navigating-challenges-in-uzbekistan-water-energy-food-environment-nexus/

Luo, M., Liu, T., Meng, F., Duan, Y., Bao, A., Frankl, A., & De Maeyer, P. (2018). Spatiotemporal characteristics of future changes in precipitation and temperature in Central Asia. International Journal of Climatology, 39(3), 1571–1588. https://doi.org/10.1002/joc.5901

Micklin, P. (2010). The past, present, and future Aral Sea. *Lakes & Reservoirs Science Policy and Management for Sustainable Use*, *15*(3), 193–213. https://onlinelibrary.wiley.com/doi/10.1111/j.1440-1770.2010.00437.x

Ministry of Water Resources of the Republic of Uzbekistan (MWR) (2018). Statistical Information about Water Consumer Association Activities in the Provinces of Uzbekistan and the Republic of Karakalpakistan. *Ministry of Water Resources (MWR) of Uzbekistan.*

Ministry of Water Resources of the Republic of Uzbekistan (MWR), 2023. Water resources of the Republic of Uzbekistan: current status and future plans. ADB knowledge Events. Yellow River Ecological Corridor (YREC) Seminar Series: Institutions and Governance for a Water Secure and Resilient Yellow River Basin 26 May 2023. https://events.development.asia/system /files/materials/2023/05/202305-water-resources-republic-uzbekistan-current-status-and-future-plans.pdf

Murray-Rust, H., Abdullaev, I., ul Hassan, M., Horinkova, V., (2003). Water productivity in the Syr-Darya River Basin. Colombo, Sri Lanka: International Water Management Institute (IWMI). v, 75p. (IWMI Research Report 067) doi: http://dx.doi.org/10.3910/2009.072

Narbayev, M., & Pavlova, V. (2022). The Aral Sea, Central Asian Countries and Climate Change in the 21st Century. United Nations ESCAP, IDD, April 2022. Bangkok.

Nishonov, B. E., Kholmatjanov, B. M., Labzovskii, L. D., Rakhmatova, N., Shardakova, L., Abdulakhatov, E. I., Yarashev, D. U., Toderich, K. N., Khujanazarov, T., & Belikov, D. A. (2023). Study of the strongest dust storm occurred in Uzbekistan in November 2021. Scientific Reports, 13(1). https://doi.org/10.1038/s41598-023-42256-1

OECD (2020). Overview of the use and management of water resources in Central Asia. http://cawater-info.net/library/eng/overview-wm-ca-en.pdf

OECD (2021). Toolkit for Water Policies and Governance: Converging Towards the OECD Council Recommendation on Water, OECD Publishing, Paris https://doi.org/10.1787 /ed1a7936-en

OECD (2022), Financing a Water Secure Future, OECD Studies on Water, OECD Publishing, Paris https://doi.org/10.1787/a2ecb261-en

Orlovsky, N. S., Orlovsky, L., & Indoitu, R. (2013). Severe dust storms in Central Asia. *Arid Ecosystems*, *3*(4), 227–234. https://doi.org/10.1134/s2079096113040082

Pachauri, R. K., Allen, M. R., Barros, V. R., Broome, J., Cramer, W., Christ, R., ... & van Ypserle, J. P. (2014). Climate change 2014: synthesis report. Contribution of Working Groups I, II and III to the fifth assessment report of the Intergovernmental Panel on Climate Change (p. 151).

Rakhmatova, N., Nishonov, B. E., Kholmatjanov, B. M., Rakhmatova, V., Toderich, K. N., Khasankhanova, G. M., ... & Belikov, D. A. (2024). Assessing the Potential Impacts of Climate Change on Drought in Uzbekistan: Findings from RCP and SSP Scenarios. Atmosphere, 15(7). https://doi.org/10.3390/atmos15070866

Sadykov, A.(1975). Irrigation of Uzbekistan. FAN UzSSR, volume 1.

Sadyrov, S., Tanaka, K., Satylkanov, R., Khujanazarov, T., Touge, Y., & Fujita, K.(2024). Modelling runoff components and hydrological processes in glaciated catchments of the inner Tien-Shan, Kyrgyzstan. Frontiers in Earth Science, 11. https://doi.org/10.3389/feart.2023.1306476

Saida, N. (2023, July 6). The Taliban's new canal threatens water security in Uzbekistan and Turkmenistan. The Diplomat. https://thediplomat.com/2023/07/the-talibans-new-canal-threatens-water-security-in-uzbekistan-and-turkmenistan/

Schmidt, S., Hamidov, A., & Kasymov, U. (2024). Analysing Groundwater Governance in Uzbekistan through the Lenses of Social-Ecological Systems and Informational Governance. International Journal of the Commons, 18(1). https://doi.org/10.5334/ijc.1322

Shukla, P. R., Skeg, J., Buendia, E. C., Masson-Delmotte, V., Pörtner, H. O., Roberts, D. C., ... & Malley, J. (2019). Climate Change and Land: an IPCC special report on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems.

Sokolov, V., 2023. Uzbekistan is implementing the national strategy for the management and development of irrigation for 2021-2023. Available at https://www.gwp.org/globalassets /global/gwp-cacena_files/en/pdf/uzbekistan-water-strategy-2023-sokolov.pdf

Sorg, A., Bolch, T., Stoffel, M., Solomina, O., & Beniston, M. (2012). Climate change impacts on glaciers and runoff in Tien Shan (Central Asia). Nature Climate Change, 2(10), 725–731. https://doi.org/10.1038/nclimate1592

SUEZ (2023). Water conservation and efficiency in Uzbekistan: an inspiring example for the African continent. Central Asia relies heavily on water for agricultural production, with over 80 percent of the region's water being used for this purpose. https://www.suez.com/en/africa/news/water-conservation-and-efficient-usage-in-uzbekistan-has-become-a-top-priority-at-the-presidential-level

The Economist (2023, February 16). The Taliban are digging an enormous canal. Article.

https://www.economist.com/asia/2023/02/16/the-taliban-are-digging-an-enormous-canal

1. Toderich, K., Matsuo, N., Khujanazarov, T., Shomuradov, Kh., Yamanaka, N., Tanaka, K., (ed.) (2024). Halophytes of the Aralkum Saline Desert. Book.

Umirbekov, A., Akhmetov A., Gafurov, Z., (2023). Research Report water-agriculture-energy nexus in Central Asia through the lens of climate change. Central Asia Regional Economic Cooperation (CAREC) Institute. https://hdl.handle.net/10568/128220

UN Development Program Report, (2016). Sustainable Management of Water Resources in Rural Areas in Uzbekistan: Technical Capacity Building (Component 2). https://www.undp.org/ uzbekistan/projects/completed-water-resources-rural-areas-uzbekistan

Uz.daily.uz (2023). The goal of the "green" development of Uzbekistan is to achieve environmental safety and sustainable development. https://www.uzdaily.uz/en/post/81789/

Uzstat, (2024). "Demographic situation in the Republic of Uzbekistan - 9/5/2024". https://stat.uz/uz/

Varis, O. (2014). Resources: Curb vast water use in central Asia. *Nature*, *514*(7520), 27–29. https://doi.org/10.1038/514027a

Vinokurov, E. (ed.), Ahunbaev, A., Chuyev, S., Adakhayev, A., Sarsembekov, T. (2023) Efficient Irrigation and Water Conservation in Central Asia. Reports and Working Papers 23/4. Almaty: Eurasian Development Bank

Vinokurov, E. (ed.), Ahunbaev, A., Usmanov, N., Sarsembekov, T. (2022) Regulation of the Water and Energy Complex of Central Asia. Reports and Working Papers 22/4. Almaty, Moscow: Eurasian Development Bank.

Vinokurov, E. (ed.), Akhunbaev, A., Chuyev, S., Adakhayev, A., Sarsembekov, T. (2024). Drinking Water Supply and Sanitation in Central Asia. Report 24/5. Almaty: Eurasian Development Bank.

WB (2016). Uzbekistan- Systematic country diagnostic: Систематическая диагностика страны по Узбекистану (Russian). Washington, D.C.: World Bank Group.

WB (2019a). Agriculture Sector. Independent Evaluation Group, Project Performance Assessment Report 134622. Washington, DC: World Bank.

WB (2019b). Project Assessment Report: UZBEKISTAN Irrigation and Drainage Interventions to Support the Agriculture Sector March 29, 2019.

WB (2020). Uzbekistan - Water Services and Institutional Support Project (English). Washington, D.C.: World Bank Group. http://documents.worldbank.org/curated/en/8021115843 24088462/Uzbekistan-Water-Services-and-Institutional-Support-Project

WB (2022). Toward a Prosperous and Inclusive Future: The Second Systematic Country Diagnostic for Uzbekistan (English). http://documents.worldbank.org/curated/en/933471650320 792872/Toward-a-Prosperous-and-Inclusive-Future-The-Second-Systematic-Country-Diagnostic-for-Uzbekistan

WB (2023). Uzbekistan Infrastructure Governance Assessment.

WB (2024). Uzbekistan - General Water Security Assessment (English). Washington, D.C.: World Bank Group. http://documents.worldbank.org/curated/en/099062424121035288 /P1700301356bad0519ce81fc 808f542aeb

Wegerich, K., 2007. A critical review of the concept of equity to support water allocation at various scales in the Amu Darya basin. Irrigation and Drainage Systems, 21, pp.185-95.

Wegerich, K. (2010). Politics of water in post-soviet Central Asia. In Dominic Heaney (Ed.), Eastern Europe, Russia and Central Asia 2011, 11th Edition. London: Routledge, 43-47.

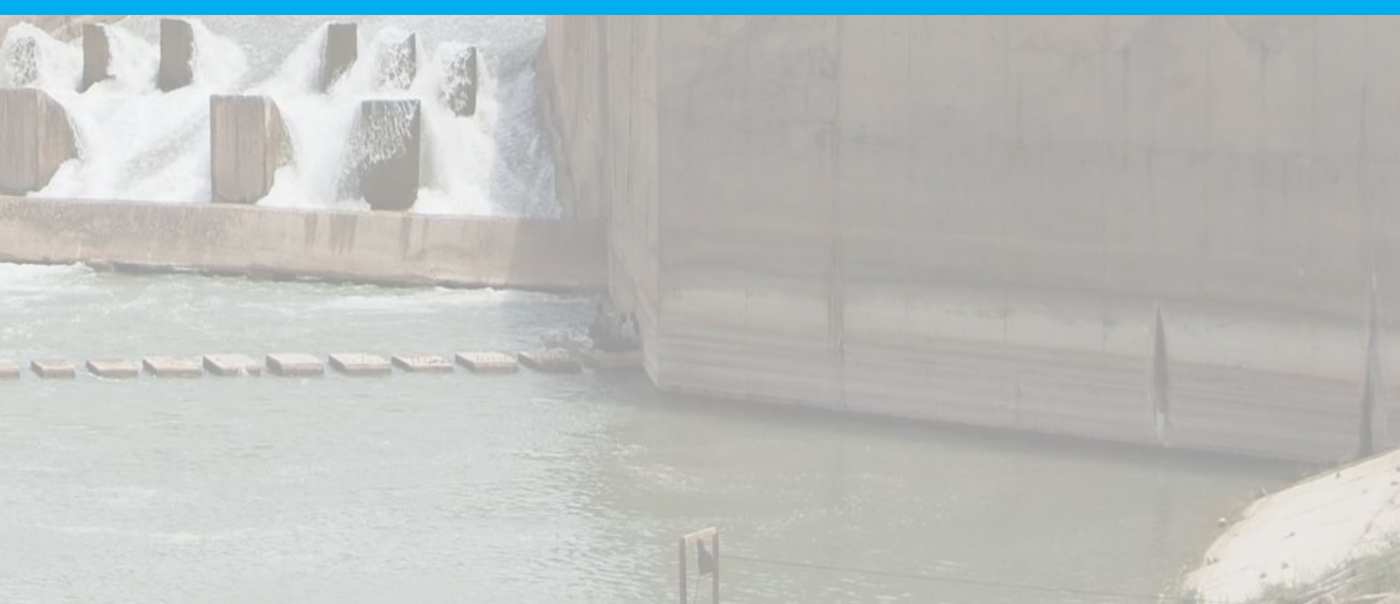
World Population Review, (2024). Water Stress by Country. https://worldpopulationreview.com/country-rankings/water-stress-by-country

WRI (2024). Aqueduct 4.0: Updated Decision-Relevant Global Water Risk Indicators. https://www.wri.org/research/aqueduct-40-updated-decision-relevant-global-water-risk-indicators

Xenarios, S., Shenhav, R., Abdullaev, I., & Mastellari, A. (2018). Current and future challenges of water security in Central Asia. In Water resources development and management (pp. 117–142). https://doi.org/10.1007/978-981-10-7913-9_5

Zomer, R. J., Xu, J., & Trabucco, A. (2022). Version 3 of the Global Aridity Index and Potential Evapotranspiration Database. Scientific Data, 9(1). https://doi.org/10.1038/s41597-022-01493-1

TURKMENISTAN



List of Abbreviations

ASBP	Aral Sea Basin Program
BWMA "Amudarya"	Amudarya River Basin Water Management Association of ICWC
CAPT&DGT	Collection of acts of the President of Turkmenistan and decisions of the Government of Turkmenistan
FAO	UN Food and Agriculture Organization
ICWC	Interstate Coordination Water Commission of IFAS
ICSD	Interstate Commission for Sustainable Development of IFAS
IFAS	International Fund for Saving the Aral Sea
GMT	Gazette of the Mejlis of Turkmenistan
GWP	Global Water Partnership
GWP CAC	Global Water Partnership for Central Asia and Caucasus
GoT	Government of Turkmenistan
GWU	Group of water users
MoAT	Ministry of Agriculture of Turkmenistan
MNPT	Ministry of Nature Protection of Turkmenistan
MWET	Ministry of Water economy of Turkmenistan
NEAP	National Environmental Action Plan
NISSI	National Institute of State Statistics and Information of Turkmenistan
PA	Production Associations
PD	Production Directorates
SCWET	State Committee of Water economy of Turkmenistan
SCT	State Statistics Committee of Turkmenistan
SIC ICWC	Scientific Information Center of Interstate Coordination Water Commission
SIC ICSD	Scientific Information Center of Interstate Commission for Sustainable Development
UNECE	United Nations Economic Commission for Europe
UNFCCC	United Nations Framework Convention on Climate Change
UNCCD	United Nation Convention to Combat Desertification
WUA	Water Users Association
WUG	Water Users Group

EXECUTIVE SUMMARY

The problem of rational use and conservation of water resources of Turkmenistan is becoming an important aspect of sustainable development of the country. The climate is changing, droughts are more frequent and severe, unpredictability is increasing. The country is facing such serious challenges as increasing the sustainability of food systems, overcoming the growing threat of water shortages and land degradation. Due to more active anthropogenic and natural factors, including climate change, these threats are further intensified. Despite significant differences between the available scenarios in the forecasts, they all expect an increase in average annual temperature, which will lead to further consequences of climate change. Along with the increase in temperature with a view to 2100, a slight increase in precipitation is predicted in the short term, but in the long term, a decrease in annual precipitation is predicted, this will affect the hydrological cycle, which will accordingly affect the availability of water. After 2050, the main impact of climate change should be expected to be a change in the intra-annual distribution of river runoff. On average, the total volume of water withdrawal from natural sources in the country is about 28 km3 annually. However, if we consider the data for recent years, they are lower than the average long-term indicators.

The current agriculture in the country with monoculture cultivation on large territories based on state orders under outdated irrigation practices, often lead to low productivity of crop production. This accordingly reduces the level of food supply, cotton raw materials for the textile industry and the productive use of natural resources. It is important to understand the situation with water resources in Turkmenistan, the specifics and functions of water for effective water management in the country. All regions of Turkmenistan experience a shortage of water resources, which is paramount for farmers. For rural residents, who make up half of the population of Turkmenistan, along with livestock farming, crop production is the main source of food and income. The most critical situation is in the lower reaches of rivers and main canals. Uneven water distribution is observed within the lower reaches. The aggravation of the problem of “upper - lower reaches”, an increase in unauthorized water withdrawal in the upper reaches are observed. Complications are expressed on transboundary rivers, despite the existing agreements on mutual use of border rivers and waters along common borders. Agreements on water use exist with Iran and Uzbekistan, but such agreement needed to be concluded with Afghanistan as well. Against this background, with further degradation of water management infrastructure, the likelihood of dispute situations increases. The situation on the irrigated lands of the Dashoguz velayat located in the lower reaches of the Amu Darya is the most acute. Here it is aggravated by the growth of salinization of lands and the consequences of the Aral crisis. In general, two thirds of irrigated lands in the country need to improvement of their ameliorative condition.

The current limitation in the volume of water for soil leaching is caused by the increase in water deficit in recent decades. As a result, the yield of crops, for the cultivation of which most the country's water resources are consumed, is significantly reduced. The measures taken to combat the degradation of irrigated lands and pastures under the intensive agricultural production should be strengthened and prevented. Today, the water supply services provided to the country's irrigated agriculture are insufficient for the growing needs of this sector, although it consumes over 90% of the country's water resources and accounts for most water losses. A significant portion of irrigation water losses occurs in the systems of its transportation from water canals to the farm and directly in the fields.

After gaining independence, the management system, nature and structure of water users, exit from the previous closed system to the regional one, development of market relations among water suppliers and water users were changed in the country. The processes occurring in the environment and growing needs for water resources in the Central Asian region became obvious. There is a large gap between the amount of water taken from the sources and the amount of water consumed by irrigated crops. In addition to natural causes such as evaporation, filtration, a certain part of water losses occurs due to organizational and technical reasons due to uncoordinated management, water leaks from outdated water devices, water regulation units and other hydraulic structures. Water use in irrigated lands is not carried out at a sufficient level, which is due to both the poor engineering status of irrigation systems, which consist mainly of earthen canals, ineffective surface irrigation and the poor irrigation planning on part of the cultivated lands.

About 1,8 mln. ha out of 40,2 mln. ha of agricultural land (the total area of the country is 49,1 mln. ha) are occupied by irrigated agriculture. Cotton, winter wheat, rice and sugar beet remain the main and mandatory crops for sowing. The cultivation of cotton and winter wheat are included in the state order system with the total cultivated area 1,3 million ha or up to three quarters of the total area of irrigated lands in the country. The available budget of water management organizations for regular O&M is not sufficient, in these conditions, the performance and level of technical equipment of water structures continues to decline. Accordingly, under the such conditions, it is difficult to maintain the technical condition, carry out basic maintenance of equipment and water bodies in the irrigated lands and reliable water supply for population.

Currently, the level of watering of pastures is less than 65%, which negatively affects the condition of natural pastures. If the situation with watering does not improve, then the degraded areas will increase, desertification will intensify even more. Due to the deterioration of the condition of pastures, livestock farming will not be able to bring the expected profit, which in the future may lead to a sharp increase in prices for meat and dairy products. The Karakum desert occupies 80% of the territory and most sheep, goats and camels graze there. Irrigation to restore the natural productivity of desert pastures shall be considered a priority urgent measure to be implemented as well.

The ecosystems are becoming especially vulnerable, and Turkmenistan is also obliged to support them. The availability of the minimum environmental flow of the Amu Darya is of serious concern. The river delta suffers from a decrease in water flow and poor quality, which has a negative impact on ecosystems. The Aral Sea crisis that is already taking place, the situation in the Aral Sea region, including the territories of Turkmenistan and Uzbekistan, has seriously worsened and this tendency may continue in future, if there is a further increase in the irrevocable water withdrawal from the Amu Darya.

In the country's water resources management, shall be elaborated comprehensive strategy for controlling water demand and water use, to eliminate undesirable situations between competing parties and sectors. In increasingly complex water conditions, an obstacle to the implementation of adaptation measures and the reduction of climate risks will be the excessively broad distribution of responsibilities for water development and management. Regarding the status and functional capabilities for planning and implementing adaptation measures in the water sector, the current organization of water management activities shall be certainly optimized. In the water management structure, along with the organizations responsible for the operation of water sources, irrigation and drainage networks, there are organizations that carry out repair and construction work. The problem here is that priority finances are given to construction work and commissioning of new facilities to the detriment of repair work to support and reconstruct under normal operating conditions the components of existing water supply systems, improve management and preventive measures to reduce river and groundwater flow.

In recent decades, strategic plans have been based on the use of the administrative territorial rather than hydrographic principle in water management.

In the near future, the most significant factors in water demand will be demographic growth, industrial production, technological costs for flow regulation, and it is also worth mentioning the increase in Afghanistan's water needs. Turkmenistan, like most countries in the Central Asian region, is aiming for industrial and agricultural development. In the agricultural sector, water demand will depend on the future population increase, consumption volumes, government policy in agriculture in ensuring food security. In parallel, the climate change increases uncertainty, so that an raise in temperature and evaporation will lead for high crop water requirement.

The country's water resources are already used in full and therefore meeting growing water needs is possible only by increasing the efficiency of using share of transboundary flows and national water resources. In any case, the household and drinking needs of the population should remain the priority. In this case, the essence of the adaptation strategy and action plans is to achieve a country's water security, which is defined as the use of the productive potential of water. Along with the strategy of purely engineering approaches, strategies for developing the potential in water resources management, overcoming structural obstacles in the water sector will be effective. To achieve sustainability goals, it is necessary to develop sound management and effective institutions. Based on this, when implementing the water security promoted for the sector as a priority, the introduction of IWRM is considered a key adaptive measure. In the future, work in the water sector should be built on close stakeholders' partnership at the national and Central Asian regional levels.

In the country's water and agricultural sector, it is important to focus on the regional perspective to improve the management of scarce water resources. Potential measures shall include support for the rational use of irrigation water and cultivated land, primarily high-water efficiency. To prevent a decline in the socio-economic conditions of local communities caused by the deterioration of the water infrastructure, it is necessary to construct new and restore existing hydraulic structures. It is also required to carry out work to clean and restore the bed of on-farm canals, other technical methods for reducing losses in the beds of irrigation canals, build new and expand the capacity of existing reservoirs. Maintaining a high technical condition of the irrigation system is one of the key decisions in the complex of water management works. It is necessary to significantly improve the condition of drainage systems - these canals require periodic repair and cleaning work, as well as flushing saline lands in the autumn-winter period.

Under the current situation in the water sector, a clear prioritization of water uses areas, development and implementation of comprehensive measures to increase water productivity in all sectors is an urgent need. It is necessary to actively implement measures to improve the organizational structure of water resources management, traditional technical measures for water conservation, increasing the volume of local runoff, improving strategic planning of the production structure and development strategies for the main water-consuming sectors of the economy.

Improving farm water use can be considered as one of the main mechanisms for increasing water reserves. Measures should include the use of high-quality irrigation by farmers using water-saving methods, technologies and engineering means. The crop irrigation method should be selected in accordance with specific natural, climatic and socio-economic conditions. The most realistic measures are efforts to introduce crops and varieties in agriculture, and products in industry that require the least amount of water per unit of cost of the final product. Taking this into account, it is important to optimize the cultivation of wheat and cotton areas at the state level.

Thus, it is necessary to optimize the allocation of crops considering the needs of the country and minimize the use of water resources, concentrate agricultural production on the most fertile lands, and reduce irrigated agriculture on low-fertility lands and areas too remote from the irrigation source. When improving water resources management, it is important to achieve it also by strengthening of the institutional and legal potential -organizations, rules, incentives, practical guidelines, staff development, investments and increasing competence, knowledge, skills. To overcome challenges, one should not focus only on supply-oriented technological solutions, but also pay attention to the management of process participants. In this context, as an example of solutions, it can be indicated that only in the presence of farm land property ownership, the possibility of choice and profitability in the irrigated agriculture can stimulate efforts and farmers productive investments in rational water use.

In drinking and domestic water supply, attention and efforts should also be increased especially true improvements into the rural water supply, water supply and sanitation of small settlements. The implementation of improvement measures in the irrigation sector will simultaneously significantly solve the problems of rural water supply and achieve the country's targets on SDGs for everybody's equal water access and usage.

It is recommended to more extensively include the components of environmental protection of water ecosystems and management in the sector strategy. First, this concerns ensuring rivers' environmental flows, protecting catchment areas and preserving aquatic ecosystems - river and marine.

Given the very high transboundary nature of the country's water resources and existing situation, international cooperation is an important basis for implementing measures to mitigate the consequences of declining water resources and the impacts of climate change in the Central Asia region. This plays an important role in solving regional food and environmental problems. It is necessary to strengthen interaction with neighboring countries and develop flexible mechanisms for productive international cooperation.

Investments in the infrastructure of the Turkmenistan water resources sector are a factor in growth and development. Adequate financing of water resources management is important for reducing uncertainty and managing risks. There is a need to increase the ability of farmers to pay for water supply services as well. An appropriate tariff policy for sustainable water services shall be considered in government programs to provide participation of all water users in covering O&M cost for the maintaining of existing infrastructure. The state budget is the main source of funding, and the government strengthens its effort to implement water projects through adopted social-economic development programs, however, today many innovations and initiatives and their promotion depend on external funding and technologies. Therefore, strengthening and deepening of cooperation within the joint projects with the international donors and financial institutions can promote introduction of innovations to the water sector and speed up the whole process of reforms aiming to save and rational water consumption.

Thus, the future water security of Turkmenistan require to implement integrated actions for better water management and conservation, apply sustainable agricultural practices, climate change adaptation strategy along the country, improved governance and policy frameworks, deepening of regional and international cooperation, develop comprehensive monitoring and evaluation system, infrastructure upgrading by targeted investment into water supply and sanitation systems both in urban and rural areas.

CHAPTER 1. AVAILABILITY, COLLECTION AND DELIVERY OF WATER

1.1. Available water resources. Water balance

In the context of water resources, the climatic conditions of Turkmenistan are characterized by extremely low levels of precipitation. The greatest amount of precipitation over the territory is observed in the mountains and foothills - on average up to 398 mm (Koyne-Kesir village), the least - over the Kara-Bogaz-Gol Bay (95 mm) and the north-east of Turkmenistan (105 mm). Rains are typical for the winter season, mainly in October and April.

There is practically no surface runoff on the territory of Turkmenistan, as more than 80% of the country's territory does not have permanent surface runoff. Occasionally water runoff can occur only in some places formed by takyr and takyr-like soils after rains of more than 3-5 mm. This is the local flow and reserves of underground water resources of the desert that occupies about 80% of the area of Turkmenistan, which is very important, despite their small amount. Since local runoff affects only areas with weakly permeable soils and its volume is small, groundwater supplies are limited. Meanwhile, the desert's own water resources are insufficient for the economic development of the desert region. Since the volumes of these water resources are small on a national scale, they are not considered in the water balance of Turkmenistan Review of environmental indicators of Turkmenistan.

The State Water Fund of Turkmenistan constitute from rivers, reservoirs, lakes, irrigation canals and drainage collectors, as well as other surface water bodies and watercourses, groundwater and the water of the Caspian Sea within the state border of country.

In total, the average annual flow in the country is about 39,5x10^6 m^3 as for the beginning of 2000th (Figure 1). Drainage waters volume is estimated at 5,6-6,0x10^9 m^3/year, the total wastewater flow of the country is 8,74x10^9 m^3/year) (Balakaev et al., 2009). As the volumes of drainage water generated in the territory of Uzbekistan, this figure in previous years reached a value exceeding 11x10^9 m^3/year (MWET, 2000). In recent years, there has been a decrease in transit waters out of interstate collectors from the territory of the Republic of Uzbekistan (Balakaev et al., 2009).

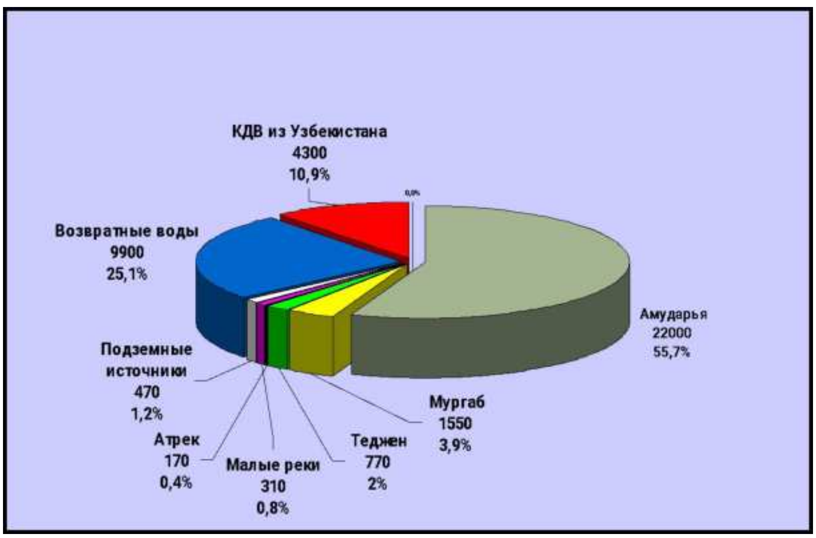


Figure 1. Summary indicators for water resources of Turkmenistan

Some of the drainage water is weakly mineralized and in practice there are opportunities for reusing wastewater in various ways. In the areas where occur water shortage, the drainage is used in irrigation by mixing with river water. Thus, drainage waters make up and will likely continue to make up a significant share in the balance of water resources.

The same can be noted regarding sea waters as water resources. Their use has especially increased in the western part of the country - on the coast of the Caspian Sea.

Regarding groundwater being part of the water fund, in Turkmenistan it is mainly located in Kopetdag, the Great Balkan, Koytendag areeas. Groundwater is formed due to filtration losses from foothill gorges and large canals. Fresh groundwater in Turkmenistan is accumulated in Yaskhan, Karabil, Badkhyz and other places (Table 1.1) (Balakaev et al., 2009; Balakaev et al., 2013).

Underground fresh water is distributed over 35% of the territory of Turkmenistan. As of 2013, more than 200 freshwater deposits (with mineralization up to 1 g/l) have been explored in Turkmenistan, of which 81 deposits have been approved for exploitation. Volumes of groundwater with total reserves – 9,3804x10^6 m^3/day or 3,4x10^9 m^3/year. Proven reserves are 6x10^9 m^3, and forecast volumes are 9x10^9 m^3 (Bayramova, 2012). About 60% of underground water is formed due to filtration losses of surface runoff. The predominant part of groundwater, suitable in terms of quality indicators is located in hard-to-reach, remote areas from populated areas. In most cases, these waters have a mineralization higher than permissible and are unsuitable for drinking purposes. The arid and hot climate, low amount of precipitation, as well as the complex geological and tectonic structure of the territory contribute to the accumulation of predominantly highly mineralized groundwater. Fresh groundwater is formed mainly in mountainous areas, where the bulk of atmospheric precipitation falls and water losses through evaporation are minimal. In addition to mountainous regions, fresh and brackish waters are also available in the Karakum Desert in the form of lenses “floating” on salt waters (UNDP, 2024). They can often be used for watering livestock, since the permissible suitability indicators for them are higher than for humans.

Table 1. Groundwater resources of Turkmenistan

Location	Basin area, km^2	Share of lens fresh water in groundwater reserves, %
Badkhi	3000	27
Karabil	6765	36
Yaskhan	2000	15
Dzhilikul	2950	12
Eastern Zaunguz	1000	5
Cherkezli	400	3
Repetek	300	1
Balkuin	650	<1

The groundwater share in the country’s water balance is estimated approximately 2%.

There are rivers in the southern and eastern peripheral regions of the country. Most watercourses in the country have the features of rivers formed in arid areas: low flow, uneven flow distribution, fluctuations in water flows during the off-season period. Especially in mountain rivers, more than 70% occurs in the spring and winter seasons. After intense rainfall, floods and flooding occur.

There are small natural lakes, but most of them has saline water. The annual supply of inland water resources per capita is 232 m^3/year, which is lowest in the Central Asia.

In total, the average long-term flow volume of large and small rivers of Turkmenistan is 23,4x10^9 m^3/year (Table 2). The water resources of Turkmenistan are formed mainly from the runoff of the Amu Darya, Murgab, Tedjen and Atrek rivers, as well as small rivers, underground and canal lenses. The country's long-term average water resources average 22,2-25,3x10^9 m^3, of which those belonging to the Amudarya River is 22,15x$10^9$$m^3$, to the Murgab River – 1,55x10^9 m^3, to the Tedjen River – 0,77x10^9 m^3 , to the Atrek River – 0,17x10^9 m^3, to the smaller rivers of the foothills – 0,15x10^9 m^3 and groundwater – 0,47 x10^9 m^3(Volovik, 2010; Balakaev et al., 2013).

In percentage terms, the freshwater resources of Turkmenistan consist mainly of the agreed share of transboundary rivers: Amu Darya, as well as Murgab (6,5%), Tedjen (3,5%), Atrek with the tributaries Sumbar and Chendyr (UNDP, 2012,1; Aganov & Ovezmuradov, 2018). Small rivers are mainly located in high mountain areas, mostly on the northeastern slope of the Kopetdag. The number of floods can vary from one to three per year, although in some years they do not occur at all (UNDP, 2024). During floods, the maximum flow of some rivers can reach tens or even hundreds of cubic meters per second, and the flow volume is 0,19-0,21x10^9 m^3/year. In general, the share of small rivers in the water balance is insignificant.

Without considering the Amu Darya, their total flow is 2,5–3 km^3/year (MWET, 2011; Kurtovezov, 2008; Orlovsky & Orlovsky, 2002). The country's water resources are mainly formed by the Amu Darya River with an average long-term flow of 63x10^9 m^3/year, and for the flow of 90% supply it is 55,2 x$10^9$$m^3$/year. Turkmenistan receives 22x10^9 m^3/year averagely for water availability. Amu Darya water constitutes the main water resource and is the dominant part of the country's water balance.

In the mountains of the country there are lakes of karst origin Kov-ata (in the Baharden cave) and Khorjunli (in Kugitang-Tau), their volumes are insignificant, and they do not play important role in the water balance (Kurtovezov, 2008).

Table 2. Water resources of Turkmenistan

River, Hydrometeo-rological station	Average long-term, 10^6 m^3	Volume of runoff in the overall water resource structure, %	Notes
Amu Darya, Kerki	22 000	94	In accordance with existing agreements
Murgab, Tagtabazar	1550	4,4	
Tedjen, Pulihathun	770	1,0	

Continuation of Table 2

Etrek, Chat	170	0,3	
Small rivers	310	0,3	
Fresh groundwater	470	-	Actual water intake
Return waters	9900	-	Reporting data for 2006
Collector-drainage waters flowing from the territory of Uzbekistan	4300		

1.2. Water abstraction

There are very few rivers in the country, and all of them are in border areas. River flow is entirely or largely generated outside the country. Due to the absence of high mountains with glaciers, lack of precipitation and arid climate, many rivers have low water levels and mostly dry up by the end of the summer season. River flow generated within the country is 1,55x10^9 m^3 or 1,2% of the Aral Sea Basin. Thus, there is a high transboundary nature of the country's water resources - 95% of surface waters are formed outside of Turkmenistan (Volovik, 2010; Balakaev et al., 2009; UNDP,2012,1).

On average, the total volume of water intake from natural sources annually is about 28x10^9 m^3. If we look at the data for recent years, they are below the long-term average. In 2021, water intake from natural sources throughout the country amounted to 26929,4x10^6 m^3 and in 2022- 26807x10^6 m^3. Surface water intake in 2021 was to 22898,3x10^{6}m^3 and respectively in 2022 – 22580,4x10^6 m^3 (SSC of Turkmenistan, 2022; SSC of Turkmenistan, 2023).

Table 3. Long-term average volumes of used fresh and other water resources

Item No.	Water source	Average long-term volumes of water resources used, 10^6 m^3	Used water resources, % from total volumes
1	Transboundary rivers (total)* including:	23344	97,27
1.1	Amu Darya	22000	91,67
1.2	Murgap	1044	4,35
1.3	Tedjen	232	0,97
1.4	Atrek	68	0,28
1.5	Small rivers	70	0,29
2	The groundwater	450	1,88
3	Small rivers, streams, springs, karizs	73,3	

Continuation of Table 3

4	Mudflow waters used*	50	0,21
5	Takyr water flow (95% supply)**	32	0,13
6	Desalinated waters	36,5	-
7	Wastewater volume *	109,5	-
8	Collector-drainage water*	50	0,21
Total local water resources		655,3	2,73
Total used water resources of the country		23999,3	100

The water taken from the Amu Darya is on average 22 km^3/year, which is regulated by an interstate agreement with Uzbekistan - equal water allocation at the Kerki hydropost (GoT,1996). Amu Darya river water provides more than 90% of the country's water supply. In previous decades, the share of this river was less than 90%, but in recent years the water flow of other rivers in the country has decreased significantly. In previous years, annual flow rates along the Murgab River were 1,55x10^9 m^3/year, Tedjen River the flows were 0,77x10^9 m^3/year, and for river Atrek – 170x10^9 m^3. Currently all these rivers flows have decreased significantly. The reasons are both natural and anthropogenic factors, the same process can be observed in the small rivers of the country. In practice, all water from these rivers is taken completely for various needs. Below data on the used fresh and other water resources differ slightly from the previous data (Table 3) (UNDP, 2024).

Also, surface water resources include small volumes of water that form on takyrs after precipitation (Table 4). In small quantities, the water accumulated in the takyrs is used for a short period of time, mainly taken for watering livestock grazing on the pastures of the Karakum Desert (UNDP, 2024).

Table 4. Surface water resources of desert zone from takyr and takyr-like soils

Catchment area, km^2	Average long-term runoff, 10^6 m^3	Annual flow of different supply, 10^6 m^3			
		75%	80%	90%	95%
31000	332	172	141	94	64

The fresh water from more than 130 groundwater deposits is used for drinking purposes by households and population. Before the total water use from these sources amounted to 400 – 470x10^6 m^3/year (SSC of Turkmenistan, 2002; SSC of Turkmenistan, 2009). But in 2021 the actual groundwater withdrawal amounted to 221x10^9 m ^{3}/year and in 2022 – 135x10^6 m^3 (SSC of Turkmenistan, 2022; SSC of Turkmenistan, 2023), which demonstrates a reduction of underground sources usage.

Compared to previous decades, in recent years the intake of sea water has increased due to more intensive activities in the Caspian zone, including large-scale construction and operation in the "Avaza" resort area on the coast near the city of Turkmenbashi. The withdrawal of this water in 2021 amounted to 564,5x10^6 m^3/year, and 57,5x10^6 m^3 in 2022 (SSC of Turkmenistan, 2022; SSC of Turkmenistan, 2023). The sea water in this Balkan region (velayat) is used after desalination and treatment in high-capacity plant built in the area.

In recent years, due to a reduction in specific water supply per irrigated hectare, a decrease in the volume of drainage water has been observed. The return waters accounting in the country is carried out by water management authorities, but reuse of this water is practically out of control.

1.3. Structure of water users by economic sectors

Agriculture is the dominant water consumer (Figure 2) and water consumption is averagely about 90% from total water resources of the country. In 2021, the country's water use in agriculture (including rural water supply) amounted to 16,194x10^9 m^3, and in 2022 -16,142x10^9 m^3 (SSC of Turkmenistan, 2022; SSC of Turkmenistan, 2023).

In the context of the internal water use in agriculture by regions, more water is consumed in Mary (4,764x10^9 m^3/year), Ahal (4,235x10^{9}m^3/year) , Dashoguz (4,160x10^9 m^3/ year and Lebab (3,303x10^9 m^3/ year and smaller in Balkan (0,505x10^9 m^3/ year) vilayets.

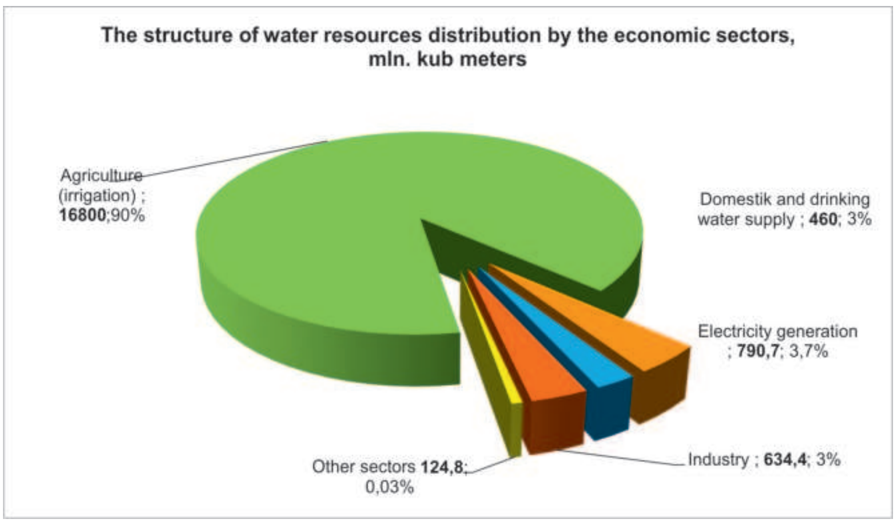


Figure 2. Structure of water users by sectors

The total water intake into the irrigation network (mainly river water) during the year ranges from 20,25x10^9 m^3 to 22,75x10^9 m^3 (Ilamanov, et. al.,1996; Hallyklychev, et al., 2014; MWET Annual bulletin, 2000; Wolovik, 2010; Balakaev, et al., 2013;), (Wolmuradov, 2018; MWET, 2011). The small part of the irrigation water is also used for rural water supply, water for livestock and wildlife, and for the pasture watering. The irrigation network often also serves as infrastructure for providing drinking and domestic water supply to rural areas of the country, as well as watering livestock.

The water consumed by other industries is insignificant (Figure 2). On average, about 2,8% of the country's total water resources (approximately 575x10^6 m^3/year) are used for drinking and household needs, but lately decreased noticeably (SSC of Turkmenistan,2002; SSC of Turkmenistan, 2009). In 2021, 459x10^6 m^3/year, and in 2022 333,2x10^6 m^3/year were used for domestic and drinking water supply (SSC of Turkmenistan, 2022; SSC of Turkmenistan, 2023). The trend towards reducing municipal water consumption can be explained by the infrastructure improvement and tariff reforms.

In 2021, 937,6x10^6 m^3 were used across the country for production purposes, and in 2022 these figures amounted to 982,7x$10^6$$m^3$ (SSC of Turkmenistan, 2022; SSC of Turkmenistan, 2023).

In general, in Turkmenistan, the volumes of water used for various needs in 2021 amounted to 17,5904x$10^9$$m^3$, and in 2022 - 17,4576 $10^9$$m^3$ (SSC of Turkmenistan, 2022; SSC of Turkmenistan, 2023). Over the last period across the country there has been a decrease in total water consumption compared to the average.

Over 40% of the volume of consumed groundwater is used for the needs of domestic and drinking water supply, about 35% for irrigation, and the rest for other needs - watering of pastures, balneology (Table 5) (Bayramova, 2012; Volovik, 2010; SSC of Turkmenistan, 2012; SSC of Turkmenistan, 2015; SSC of Turkmenistan, 2023).

Table 5. Structure of groundwater reserves usage

No	Purpose of use	Groundwater used	
		%	10^6 m^3
1	Domestic and drinking water supply	40,8	183,6
2	Irrigated agriculture	36,2	162,9
3	Balneological purposes and other needs	22,8	102,6
5	Watering of pastures	0,2	0,9
Total		100	450

The water resources of country are limited and therefore, in dry years, during mass irrigation of agricultural crops, there is tension in the water supply of various industries.

CHAPTER 2. INSTITUTIONAL FRAMEWORK FOR THE WATER SECTOR

2.1. Existing legal framework

After gaining independence Turkmenistan developed comprehensive normative legal framework for water sector governance and regulation. Especially, in recent years, the country has made significant progress in legal support, in reforming water legislation, changes have taken place considering new realities - market relations, climate change, entry as an independent country into international structures and systems on water and environmental issues. Therefore, the existing legal system is complemented by the international obligations accepted by the country. The country has joined the number of international treaties and conventions and has become a participant in several international programs and organizations. Turkmenistan became one of the first country in the region adapted the SDG indicators to the National Development Programs.

The water legislation of Turkmenistan is based on the Constitution of Turkmenistan and consists of the Water Code of Turkmenistan and other regulatory legal acts, including Laws "On Land Reclamation", "On Drinking Water",''On Specially Protected State Natural Areas'', "On Nature Protection".

The Constitution of Turkmenistan stipulates (Mejlis of Turkmenistan,1992) responsibility of the state for the preservation of natural heritage and the environment; state control over the rational use of natural resources in order to protect and ensure healthy living conditions for the population and maintain a stable condition of the environment; the right of every person to an environment favorable to life and health, and reliable information about its condition.

The Water Code is the main legislative act relating to the water sector, adopted in October 2016 stipulates equal access of the population to water. The document regulates relations in the field of sustainable and rational use of water in order to meet the needs for water resources of legal entities and individuals and is aimed at increasing the significance of water resources, ensuring water protection. The (GoT, 2016).

The Code consists of eight sections, twenty-six chapters and 120 articles. The general provisions provide definitions of the basic concepts set out in the Water Code, such as state water management organizations, integrated (complex) water resources management, basin management principle - management of the water fund according to geographical characteristics, implemented in the distribution of water resources within river basins, lakes and other water bodies. The new concepts, systems, and management principles were introduced into the document, including IWRM; basin management principle; basin water management organizations, Water Users Association (WUA), group of water users (GWU), transboundary water bodies.

The Low on Drinking Water (GoT, 2010) regulates rrelationships arising in the field of drinking water supply in the country. The law aims to provide state guarantees for the provision of drinking water to the population; determines state requirements for monitoring the quality of drinking water and its safety for human health, protecting drinking water sources and their use. Furthermore, the law establishes the legal, economic and organizational basis for the rational use and environmental protection of water from pollution, clogging and depletion, as well as the functioning of drinking water supply systems and the relationships of subjects in the field of drinking water supply.

Law "On environmental protection", regulates in the field of protection of natural resources (including water) and rational environmental management, establish the legal basis for environmental assessment, determines environmental measures, regulatory, technical and metrological support, environmental requirements for economic and other activities (GOT, 2014). The law provides for government measures during environmental emergencies, control in the field of environmental protection, the right of citizens for the environmentally favorable life and responsibility for violation of environmental legislation. The law states that legal entities and individuals whose activities affect the condition of water bodies are required to comply with environmental requirements established by the legislation of Turkmenistan and carry out organizational, technological, forest reclamation, agrotechnical, hydraulic, sanitary-epidemiological and other measures to ensure the protection of water bodies from pollution, waste, clogging and depletion.

The Law "About especially protected natural territories" is adopted for ensure the protection of marine and continental ecological systems of natural resources. (GoT, 2012). The law establishes the responsibilities of ministries, departments, citizens in the conservation of natural complexes and individual objects that have special environmental, scientific, cultural, educational, recreational and health benefits or aesthetic value. The document regulates relations in the field of organizing the management of specially protected areas, including water, natural complexes and individual objects with particular value.

The Law "On Land Reclamation", adopted in October 2018, defines the legal, economic and organizational basis for land reclamation and regulates the relations arising in this area. (GoT,2018). Land reclamation shall be intended a complex of agrotechnical, hydrotechnical, forestry engineering, land clearing, chemical and other reclamation measures aimed at radical improvement of adverse natural (hydrological, soil, agroclimatic) conditions of land with the aim of rational and stable use of land resources. Land reclamation shall be carried out for the following purposes: (a) rational use and protection of water resources; (b) improvement of ameliorative condition of land; (c) increase of fertility and sustainable preservation of land; (d) increase of agricultural production as a result of restoration and stable preservation of soil fertility on agricultural land; (e) involvement of unused and low-productive land into agricultural turnover by carrying out ameliorative measures; (f) protection of land from mudflow and flood waters, wind and water erosion, increase of ground water level; (g) development of new land areas; and (h) ensuring watering of pastures.

Sanitary Code of Turkmenistan, adopted in 2009 defines rights and obligations of citizens, state bodies of local self-government, enterprises, institutions, organizations to ensure sanitary and epidemiological well-being (GoT, 2009). The Code defines the legal, economic and social conditions for ensuring the sanitary and epidemiological well-being of the population, implementation and protection of the rights of citizens to a favorable environment, related rights and legitimate interests of citizens.

Relevant articles of the Criminal (dated May 10, 2010) and Administrative (dated August 29, 2013) Codes provide a legal basis for the rational use and protection of water resources.

2.2. Water management governance - institutional framework

The state of the country's water sector is characterized by the presence of complex multifaceted processes, which, after gaining independence, are determined by changes in the management system, the nature and structure of water users, a shift from the previous closed system into a regional one, the development of market relations among water users, water suppliers and other interested parties, the growing needs for water resources, and ongoing environmental processes - climate change, economic processes. At the initial stage of independence, the above led to a sharp increase in water users, a weakening of the financial capabilities of water protection and water management organizations and stakeholders, a weakening of the human resource potential of organizations as well as other difficulties. The situation was becoming even more complicated due to the intertwining of regional and national aspects in Central Asia, the high levels of transboundary characteristics in the country's water resources, and the need to meet the needs of natural complexes. A number of related government and business entities are involved in the ongoing work and activities related to water resources. The national level - government structures, ministries, departments and other central government bodies - have the authority to make decisions within the framework of their responsibility. Conventionally, they can be divided into primary and secondary stakeholders.

In accordance with the Water Code of Turkmenistan, state management in the field of water use and protection is carried out by the *Cabinet of Ministers of Turkmenistan*, authorized state bodies in the field of water use and protection, local executive authorities and local self-government (GoT, 2016).

The activities of the authorized state bodies in this sector are headed by the Cabinet of Ministers of Turkmenistan. The authorized state bodies in the field of water use and protection include several bodies.

The State Committee of Water Economy of Turkmenistan (SCWET) is the authorized body in the water management. The authorized government body in the field of environmental protection is the *Ministry of Environmental Protection*. The authorized government body in the field of geology is the *State Corporation "Turkmengeology*". There are other authorized government bodies in accordance with the legislation of Turkmenistan, which functions are discussed in more detail in the next section.

In water resource management issues also involved the *Ministry of Health and Medical Industry*; municipalities: hyakimliks of five velayats (provinces) and cities, Ashgabat and Arkadag - within their "Vodokanal" ("Water Canals") structures. In relation to drinking water, the authorized body for state management of public utilities is the key authorized state body in the field of drinking water supply (GoT,2010; GoT,2018).

In general, the SCWET exercises control over the rational use of water by the consumers and the rules of operating water management systems, reservoirs and other hydraulic structures. The state level of management is entrusted to the *State Water Committee* and the *Ministry of Environment Protection* in relation to water protection, as well as their local representative offices and subordinate organizations. The body includes about 120 production associations, departments, and other enterprises and organizations. This results in a 3-stage hierarchical control system. As for the territorial level of management of the SCWET, this task is assigned to the *Production Associations* (PA) in the velayats, which are Akhalsuvkhodzhalyk, Balkansuvkhodzhalyk, Dashoguzsuvhojalyk, Lebapsuvkhodzhalyk and Marysuvhojalyk. In each etrap district (their approximate number is 50, changing due to administrative-territorial reform), Etrap Production Directorates (PD) have been created. The indicated Production Directorates, for example the PD "Tedzjensuvkhozhalyk", are the former district water administrations during the Soviet period (Figure 3). The existing management system is mainly built on a territorial principle, in which there is significant administrative intervention by local authorities, which is not always an advantage.

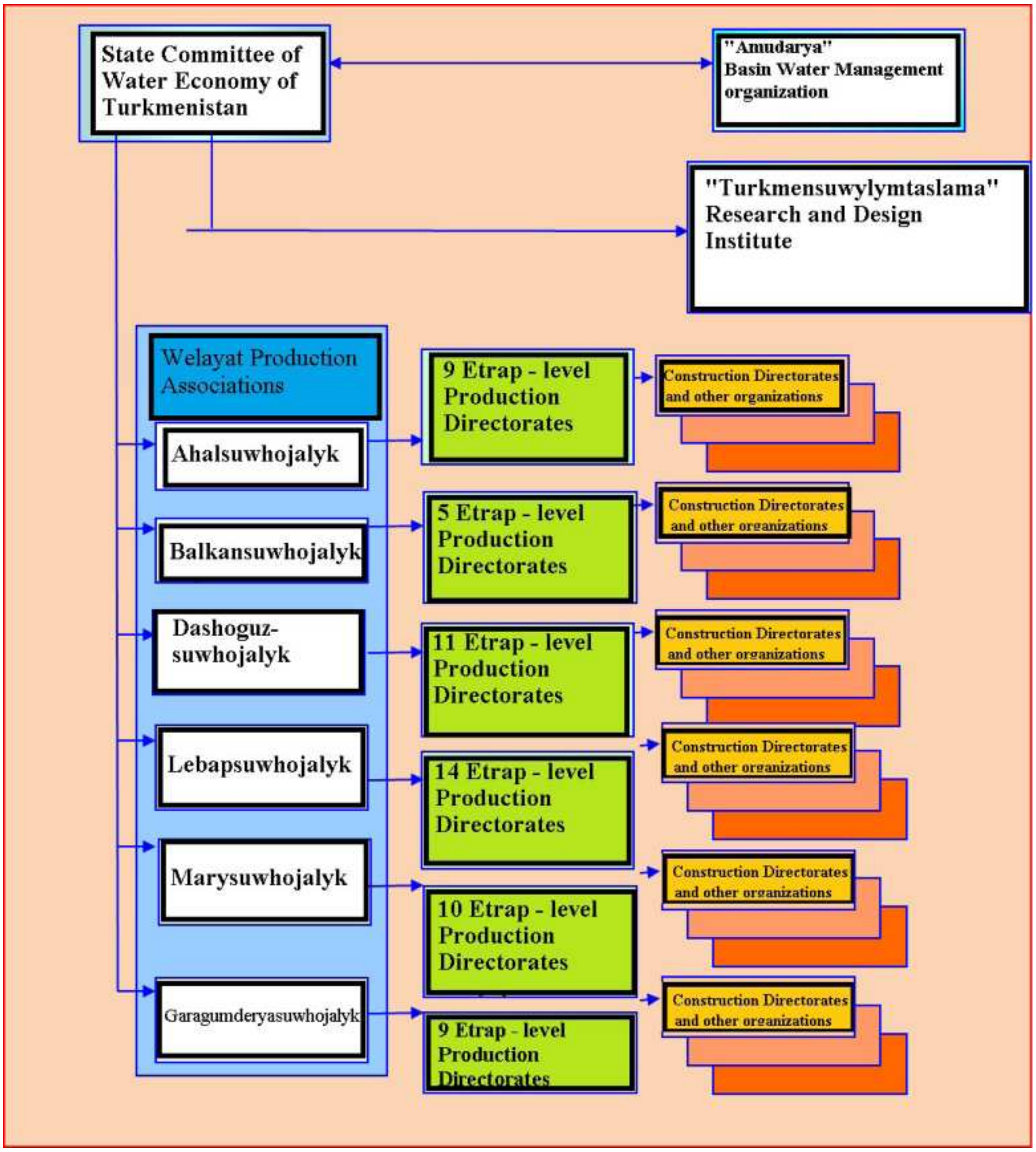


Figure 3. The State Committee of Water Economy of Turkmenistan structure

On the Karakum Canal, which is one of the main waterways of the country, management is carried out by 9 operational departments as part of the "Karakumderyasuvkhodzhalyk" Association. It has not only inter-etrap (inter-district), but also inter-velayat (inter-regional) significance. This large and significant water management organization is based on the basin principle, which is of course positive from the point of view of water management. The structure of the State Committee of Water Economy also includes construction, production, design, development and research organizations that carry out irrigation, reclamation and other work. The structure of the SCWET includes a Water Control Service with the inspection groups in the velayats.

International institutional mechanisms for water resources management in which Turkmenistan is involved include: within the framework of IFAS, the *Interstate Coordination Water Commission* (ICWC), the *Interstate Commission for Sustainable Development* (ICSD), the *Amudarya River Basin Water Management Association* (BWMA "Amudarya" ICWC), and the *UN Regional Center for Preventive Diplomacy in Central Asia* (located in Ashgabat) and others.

Thus, the Basin level of management is implemented in practice through the BWMA "Amudarya". The interstate level of water resources management in Central Asia is carried out by the Interstate Coordination Water Commission of the International Fund for Saving Aral Sea (ICWC IFAS).

The institutional structures for joint management (including financing issues) and protection of water resources, water allocation at the Iranian-Turkmen "Dostluk" reservoir on the Tedjen river are the Joint Iranian-Turkmen administration, the Ahal Velayat Water Management Production Association and the corresponding Iranian Water Management Organization.

Within the *Ministry of Environment Protection* "Hazarekokontrol" ("Caspian Ecological Control") Service carries out a share of the relevant activities in the Turkmen part of the Caspian Sea.

The water resources management system in Turkmenistan is complex, yet at the same time includes outdated approaches in combination with modern ones. Currently, there are gaps in the use and protection of water resources. There is still a lot to be done, including on access to relevant information, the transition to unified methodological approaches to assess water quality, and the use of digital information systems. Difficult conditions with access to information complicating the proper planning and effective management. Global trends in terms of information and technological exchange, open access and the ability to use the recent managerial, organizational and communication achievements are still poorly developed with insufficient application in the water sector and water consumption. Recently, digitalization has been actively promoted at the state level in all sectors of the economy of Turkmenistan. Perhaps this will have a positive impact on the area of water resources.

2.3. Functionality of the main organizations involved in water sector management

The country's state policy in the field of use and protection of water resources is aimed at ensuring the priority of protecting human life and health, preserving and restoring water resources, combining environmental, economic and social interests of society to ensure sustainable development and a favorable environment. Below are the key functions of national agencies involved in water resources management.

Cabinet of Ministers of Turkmenistan takes measures to implement state programs in the field of water use and protection; approves the main directions of rational use and protection of water, development of water management; manages the activities of authorized state bodies in the field of water use and protection; approves water consumption limits for velayats and etraps, as well as for main water bodies and economic sectors. It also cooperates with foreign states and international organizations on the use and protection of transboundary waters; exercises the right of ownership, use and disposal of the water resources of country; determines the list of hydraulic engineering and other water management structures of special strategic importance.

State Water Committee of Turkmenistan pursues and implements state policy in the field of use and protection of water bodies; takes part in the development of the main directions of state policy in the field of integrated use and protection of water; develops state programs for the development of land reclamation and water management; adopts the country's regulatory legal acts in the field of water use and protection within its competence; exercises control over compliance with the water legislation of Turkmenistan within its competence; coordinates the work on compiling the State Water Cadastre of Turkmenistan and maintains the cadastre under the "Water Use" section; exercises state control in the field of use and protection of water organizing work on the rational use and protection of water resources; approves on-farm, systemic, etrap, velayat and statewide water use plans; carries out work on state accounting of water resources and their use; coordinates and issues permits for special water use; sets water consumption limits for water users and monitors their compliance; carries out and coordinates work on state monitoring of water bodies.

The SCWET carries out activities to provide all sectors of the economy and the population of the country with irrigation water, and develop the water sector; water resources management; control over the rational use of water resources; measures to improve the operation of water management systems and environmental protection, prevention and elimination of floods, flood control measures, including protective dams management. The committee determines water consumption limits for water users in agricultural sector and controls their implementation. District water management production departments (PT "Suwhojalyk") control the main canals, reservoirs and other water infrastructure within a particular area. The District Water Management Agencies operate and keep them in working condition, distribute water to rural and other water consumers. The above also applies to inter-farm and on-farm drainage canals. The issues of operation of existing large reservoirs, main irrigation and drainage canals (including interstate collectors - joint / transit with the Republic of Uzbekistan) are handled by the velayat-level water production associations and/or the SCWET.

The issuance of permits for special water use is carried out by the Committee after the potential water user receives approval from related organizations (Geology, Nature conservation, Sanitation) and local authorities (GoT, 2016).

In accordance with the functions assigned to the SCWET and its subordinate organizations and institutions, they together carry out significant activities, including those related to achieving sustainable development goals. Its decisions regarding water resources, taken within its competence, are binding on all ministries, departments, associations, enterprises and organizations, regardless of their departmental subordination and forms of ownership, citizens, as well as foreign legal entities and individuals.

In the context of water resources, other government bodies also have certain functions related to water and health protection.

Ministry of Environment Protection exercises state control over the quality and protection of surface and groundwater, implementation of measures to prevent pollution, depletion of water resources, and their rational use; conducts state environmental examination of pre-project and design documentation for the construction and reconstruction of water management facilities and coordinates work on water bodies and in water protection zones; exercises control over the technical condition of the operation of water treatment facilities and installations at industrial enterprises, sea vessels and other floating facilities, compliance by enterprises with the conditions for special water use, compliance with the established procedure and conditions for the discharge of wastewater.

In terms of water resources, the ministry exercises control over the protection of ecological systems, the protection of surface and underground (excluding hydrothermal) waters, the marine environment, including the Caspian Sea (Khazar Sea). The ministry has separate inspection services for the protection of natural resources, including water, which operate in all velayats. The "Hazarekokontrol" Service operates in the Caspian region.

The Department of Hydrometeorology is in charge of implementing state policy in the field of hydrometeorological activities; organization of monitoring of the state of the atmosphere, marine environment, surface waters (water bodies), agricultural crops and pastures; ensuring the development and functioning of the observation network, a system for collecting, storing, processing, analyzing and distributing hydrometeorological information; preparation of draft regulations, state standards, methods and other generally binding requirements in the field of hydrometeorological activities; maintaining a unified state hydrometeorological data fund, providing information to consumers; organizing and conducting scientific research to assess and forecast the state of the natural environment; development and preparation of short and long-term forecasts of weather, water availability, crop yields and pasture vegetation, hydrometeorological phenomena, global and regional climate changes; providing with reference materials, factual and forecast hydrometeorological information; notifying about actual and expected weather conditions, and dangerous hydrometeorological phenomena, including those related to water.

Hydrogeological Service under the State Corporation "Turkmengeology" exercises state control over the use and protection of groundwater and its deposits from depletion and pollution; maintains state records of groundwater; carries out state monitoring of groundwater; maintains the State Water Cadastre of Turkmenistan in terms of groundwater deposits and organizes in the prescribed manner the transfer of this data to the authorized body; resolves other issues within its competence. It **carries** out identification and exploration of new deposits of hydromineral resources, carrying out detailed geological exploration work on applications and contracts of ministries, departments, enterprises and organizations. Its main functions also include ensuring monitoring and control over the level of pollution of groundwater deposits, compliance with the regime of protection and economic activities within water protection zones.

Utility services (economies) of municipalities in five khyakimliks of velayats and the cities of Ashgabat and Arkadag are "Vodokanals", which serve as a structural unit of local municipalities. These services provide and control the consumption of drinking water in populated areas. They also ensure the operation of sewerage systems.

The Ministry of Agriculture and local administrations on the level of regional and rural districts are also involved into the water sector, as the agricultural sector is the dominant water consumer, and the irrigated agriculture has a predominant share of freshwater losses. In practice, the country's system of agricultural relations is structured in such a way that regional and district administrations are highly involved in the process of agricultural production and implementation of plans to produce agricultural products. The water sector in the country is predominantly closely connected with the agricultural sector, including with the agricultural lands use.

The Ministry of Health and Medical Industry is the state executive body in the field of human health and sanitation. The ministry monitors the health and epidemiological safety of all segments of the population, the level of sanitation, and the quality of drinking water. The Ministry of Health has a sanitary and epidemiological service, which has its divisions in all administrative regions (velayats). They carry out sanitary, hygienic and anti-epidemic measures on the ground, including at water bodies, to prevent and eliminate infectious and parasitic diseases; carry out state sanitary and epidemiological supervision.

The inspection and supervisory services of all the listed ministries have the right to bring violators to administrative responsibility in the form of mandatory orders and warnings, impose penalties, as well as suspend or terminate the activities of an enterprise in case of violation of the rules and regulations for the use and protection of natural resources. In certain cases, it is even possible to initiate criminal charges. These rights are legalized in the relevant articles of the Administrative and Criminal Codes of Turkmenistan. In most cases, these inspection services participate in the work of state commissions for the acceptance and commissioning of new and reconstructed facilities, including water management and water purification.

The Basin Water Management Association "Amudarya" (BWMA "Amudarya", ICWC), which is part of the structure of the Interstate Coordination Water Commission, together with the Dashoguz and Lebap velayat water management associations of

Turkmenistan and the corresponding water management organizations of neighboring Central Asian countries directly represent institutional structures for joint water management resources, water allocation on the transboundary Amudarya river. Within the framework of the ICWC, coordination and planning of actions, adjustment and distribution of water resources are carried out. BWMA "Amudarya" being an interstate organization (it includes water specialists from both countries), is called upon to perform monitoring, distribution and control functions, including the use of water withdrawal limits by countries and eco-releases into downstream natural ecosystems. Accordingly, within the framework of IFAS, two organizations operate in the country, they are based in Turkmenabat and Dashoguz.

The joint Iranian-Turkmen administration for the "Dostluk" reservoir on the Tejen River carries out activities on the management (including financing issues) and protection of water resources, water allocation at the Iranian-Turkmen "Dostluk" reservoir on the Tejen River (Gerirud River).

In the aspect of water resources and the achievement of the Sustainable Development Goals to ensure the fulfillment of Turkmenistan's obligations arising from the UN conventions and programs on the environment, the *Intersectoral Commission on environmental issues* was created by special Decree of the President of Turkmenistan No. 1970 dated 23.11.2020 (GoT, 2020). The structure of the State Commission includes working groups on all environmental conventions and UN programs, as well as Deputy Chairman of SCWET. The main tasks of the Intersectoral Commission are coordination of activities at the level of khyakimlik, gengesh and public association organizations for fulfillment of the country obligations on environmental protection and timely implementation of the provision of the signed international treaties.

At present, it is necessary to increase the level of functionality of the main departments related to water sector management to fulfill the country's obligations arising from the adopted SDGs, including on water resources by strengthening of the capacity of key persons in the relevant ministries and departments, velayat and etrap divisions. The development and adoption of legal acts aimed at integration, improving the coordination of the activities of specialized and regional organizations, and subsequent practical actions in this direction will contribute to increasing the institutional capacity of the involved bodies for more effective management of the water sector.

CHAPTER 3. CLIMATE CHANGE AND WATER MANAGEMENT

3.1. Water use in agriculture - irrigation, crop structure, infrastructure

The agriculture is one of the most important sectors in the country's economy. During 2011-2020, the share of agriculture in Turkmenistan's GDP ranged from 8,5–9,8%, but before, during the the soviet time in early 1990th this figure was 20%. The decrease in late period is due to the rapid development of the fuel and energy sector. In the volume of total agricultural products, the share of crop production accounts for 32,3% and the rest is the share of livestock products (Stanchin & Lerman, 2003; Lerman et al., 2012; Lerman et al, 2014; Aganov et al., 2016; NISSI, 2017; SSC of Turkmenistan, 2020).

Currently, the agricultural sector forms the social and economic basis for the well-being of the majority of the population of Turkmenistan. The agricultural sector ensures food security and is the main sphere of life for more than half of the country's population (NISSI, 2017; SSC of Turkmenistan, 2020).

The total territory of the country is 49,1x10^6 ha, the area of agricultural land is 40,2x10^6 ha, of which more than 38x10^6 ha (77.5%) are used as pastures and less than 1,8x10^6 ha are used for irrigated agriculture. Increase in arable areas occur mainly due to the use of pasture lands. The area of the reclaimed lands suitable for future development is 17,7x10^6 ha. (SSC of Turkmenistan, 2015; NISSI, 2017). Basically, there was an increase in irrigated arable land in the period from 1990 to 2001, which amounted to 400000 ha. The area of private farms over the period early 1990s to the late 2010th increased from 0,14 to 0,21 ha (GoT, 1998; Aganov et al., 2016).

The cultivation of cotton, winter wheat, as well as rice and sugar beets are considered a priority by the state, which are included in the state order system. The dominant role belongs area of irrigated lands under wheat (760000 ha) and cotton (550000 ha). The cultivation of alfalfa in a crop rotation system is important factor in obtaining high yields from the subsequent sown/rotated crop, improving soil fertility, land reclamation conditions, this task currently assigned to the SCWET. Crops in all velayats are seriously affected by soil salinization, and the situation is especially acute in Dashoguz velayat and in some areas of Mary velayat (MWET, 2000; NEAP, 2002; UNDP, 2012,2; Hallyklychev & Atayev, 2014). About one mln. ha of irrigated land are exposed to salinization in varying degrees. Currently, two thirds of irrigated lands need to improve their reclamation status (Volovik, 2010; Nazarmamedov et al., 2013). The total length of collector and drainage systems in the country is more than 38000 km. Main collectors and spills on them, around 80 small lakes formed by the drainage water are a habitat for waterfowl and shore birds. The multi-purpose use of irrigation canals and reservoirs, including for rural water supply demonstrates wide functionality of the country water management system.

The necessary work is being carried out on open drainage canals on a regular basis and their condition can be considered satisfactory. The limitation in the volume of water for soil leaching is caused by an increase in water shortage during the last two decades. There are measures developed and implemented to combat land degradation and increase agricultural production. However, the measures shall be planned sufficiently, including cleaning drainage channels, soil leaching, land leveling, using crop rotations, applying organic fertilizers and other required farming practices.

The state sets a planned norm for the yield of the crop grown. In the last few years, it has been in the range of 19-20 c/ha for cotton, and approximately 20-21 c/ha for wheat, but the established yields are two or more times lower than the potential maximum (Stanchin & Lerman, 2003; GoT, 2011; NISSI, 2012; NISSI, 2017; Aganov et al., 2016; SSC of Turkmenistan, 2022). In some years the obtained crop yields may be affected by natural factors, including climatic and hydrological factors - low water, precipitation, temperature, including frost (Stanchin et al., 2011).

In recent years there has been a noticeable increase in the share of fruit and vegetable crops in the structure of agricultural crops and expansion of production in greenhouses. Personal subsidiary plots make a significant contribution to the production of fruits and vegetables and other products, despite the small share of the occupied area in the total irrigated area for agricultural crops in the country. They can also serve as an example of the rational use of irrigation water and low water losses in irrigated areas.

One of the most important factors for the sustainability of agricultural production is rational land use and land management. A common problem for the country is the incompletely resolved issue of land ownership, which constrains farmers for sustainable land and water resources management. A significant proportion of the rural population depends primarily on small-scale subsistence farming, based on family labor and focused on subsistence. However, their access to technology, alternative livelihoods and means of production is limited. Farmers are key water users, they are practically involved in the end section of the irrigation system, and increasing water efficiency is largely depends on their farming skills The small farming and the private sector needs to be more attracted in the use of agricultural land for crop production, but in livestock production their representation is sufficiently high (GoT,2014; Aganov et al., 2016; Aganov en al., 2019; SSC of Turkmenistan, 2023).

Until recently, farmer associations remained to be the main structural units in agriculture and, accordingly, the main consumers of water, which were dominant in terms of crop production. On average, the size of the leased area on farms does not exceed 5 ha.

Currently, farmers' associations independently manage and maintain some segments of their on-farm irrigation network and interact with state water management organizations at the district level (with "etrapsuvkhojalyks"). According to water legislation, on-farm irrigation and drainage networks are on the balance sheet of water users (that is, farmer associations or other agricultural producers) and they are responsible for its operation and financing (GoT, 2016). In practice, most of them don't have enough technical and financial resources for this, and mainly regional water management organizations have to carry out repair and construction work on the lands of farmers' associations and other water users.

The trend of a reduction in the number of farmer associations and the growth of peasant farms and other types of private agricultural producers has clearly been observed in recent years. Farmers' associations and other agricultural enterprises receive irrigation water from district water management departments in accordance with already approved limits and water use plans, depending on the type of crop and the sown area. Even with very significant subsidies from the state, most of peasant associations and its members (tenant farmers) fail to achieve financial sustainability due to low yields. It would be advisable to consider increasing the role of rural residents working in agricultural fields in the field of water use.

In Turkmenistan, within the organizational and legislative aspects of water distribution, irrigation water supply to agricultural complex is a priority. In the existing organizational system, heads of regional and rural district administrations are personally responsible for fulfilling state obligations to produce agricultural products (GoT,1998; GoT, 2016). In recent decades, as a rule, 7000 m^3/ha has been allocated annually for irrigation of main crops under state orders for cotton, and 5300 m^3/ha for wheat. These norms have remained unchanged for the last several years, and slightly less than indicated in technical document "Irrigation Regimes of Agricultural Crops in the Turkmen SSR", which still has legal force (Irrigation regimes, 1990). In addition to the type of crops, they are also differentiated depending on natural-climatic zones and soil-reclamation conditions, according to hydro-modular regions (groundwater depth and soil type).

The provision of irrigation water is mainly carried out by water intake from existing rivers and reservoirs. In the country, the use of water for agricultural needs reaches $18x10^9$ m^3/year, although in recent years it has been decreasing up between 16-17x10 ^{9} m^3. The collected water is distributed through the main canal systems of Turkmenistan, including through the longest artificial water structure in the world - the Karakum Canal with a length of over 1100 km. This canal plays an extremely important role in the water supply of irrigation lands about one million ha and ensures rural and urban water consumption, industrial, energy, transport and other sectors. Irrigation canals and reservoirs in the country are at the same time the main sources of water for drinking and household purposes of the rural population, and also serve for watering livestock and wild animals, watering pastures, fish farming and other purposes. There are also 16 seasonal regulation reservoirs with a total volume of over $3{,}1x10^6$ m^3. That includes 15 reservoirs with a total storage capacity of over $3x10^9$ m^3 and, in addition, $1{,}25x10^9 m^3$ capacity of the Iranian-Turkmen reservoir "Dostluk" on the Tejen river (Kurtovezov, 2008; UNDP, 2024). In recent years, reservoirs have been commissioned in the country using modern technologies and new building materials, including geomembranes and geotextiles to reduce filtration losses. This concerns Dostluk reservoir (2005), Bagir reservoir (2010) and Gozganchay reservoir (2014).

During the growing season and especially in low-water years (which have become more frequent in recent decades), the water supply is often incomplete and delayed, which negatively affects the crop yields. In practice, for certain other types of agricultural producers' irrigation water supply usually worsens even more, an exception may be rice and sugar beets, which are also included in the state order.

Irrigation water costs are significantly subsidized by the state from the budgets to support the rural population and ease the financial burden, as most part are not able to cover the costs of supporting the functioning and development of water infrastructure from their income. The main reasons for the further degradation and salinization of irrigated lands unguaranteed land tenure, farmers are not interested in taking action to improve the fertility of the fields they use. There was no significant progress in the transition to private land ownership. Land is allocated for rent, for use and in other forms, but not private property on a massive scale. Cultivated crops' pattern are determined by the land-distributing organizations. The provision of land for use for up to 99 years gives some optimism - if a stable continuation of this course is ensured without making significant changes. Notably, even in this setting of land use, the approach of the state order for certain cropping pattern are preserved.

The main problem in irrigated agriculture, primarily related to water losses. In the current state, the efficiency of the irrigation network varies across velayats from 0,53 to 0,84 and the average for Turkmenistan is 0,57 (Ilamanov et al., 1996; Stanchin & Lerman, 2003; Çakir, 2005; Balakaev, 2013; Volovik, 2010). The water taken from natural sources is lost during transportation through main, inter-farm and on-farm canal systems. On average, water losses in earthen canals at 1 km are 32-36 l/sec. The total length of irrigation canals is about 44000 km, which are mostly earthen and with worn-out water control devices. The length of inter-farm canals is 8677 km, and on-farm canals are 34629 km. The main part of the country's irrigation system, which was built many decades ago, is physically and morally outdated, and is characterized by low efficiency. Thus, 20% of water losses occur on the main, inter-farm canals and reservoirs and 22% on the on-farm irrigation network. In addition to natural causes (evaporation, filtration, etc.), a certain part of water losses occurs, due to uncoordinated management, water leaks from outdated water.

To eliminate unproductive losses, basically, financially strong and advanced individual farmer associations acquired these water-saving technologies. Some of them received sprinkler equipment from foreign companies as a gift, for experimental testing or advertising purposes.

The irrigation method must be selected in accordance with specific natural, soil-climatic and socio-economic conditions. The correct choice of irrigation method determines the design and cost of the irrigation system, irrigation efficiency, reclamation state of the irrigated area, crop yield, and expenses.

The main advanced irrigation methods used in the agricultural sector of Turkmenistan are sprinkling and drip irrigation. These two methods are used when watering trees in forested areas, in park areas within the city and in the suburbs in the country. Subsoil irrigation and other irrigation methods are not used widely.

The process of introducing these irrigation systems began starting from 2000s. International experts in this field indicate that the efficiency of this kind of irrigation is 70-85% (UNDP, 2024). To achieve effective sprinkler irrigation in the country require to comply with a number of conditions - the length of the system, the time of day to start watering, the duration, the growing season of the crop, the regulation of water flow from the outlets and others. For drip irrigation, there are no such restrictions on the length of the system and the time of irrigation, the effectiveness of this irrigation approach is 90-95% (UNDP, 2024). The purchase, installation and installation of a drip system per one ha is 2,630 USD, which is higher than for a sprinkler system.

Due to a number of financial, organizational, technical, personnel and other reasons, the surface method, with all its weaknesses, will remain dominant in the near future in the practice of irrigated agriculture of the country, despite the fact that the efficiency of furrow irrigation is 50-70% (UNDP, 2024).

In terms of turbidity, the Amu Darya ranks first in Central Asia and one of the first places in the world. The river water contains the sediment 3,5 kg/ m^3, and during floods it reaches 5-7 kg/m^3, which significantly complicates the functioning of the entire irrigation system and reduces the service life of water facilities.

There are main drainage canals that have a significant impact on the hydrology and pollution of the Amu Darya. A significant return water flow into the Amu Darya takes place within the Lebap velayat with the average mineralization of drainage water 2,3 g/l and flows from Uzbekistan with average mineralization 6.5-8.5 g/l/. The schematic location of the main drainage canals in the middle reaches of the Amu Darya, including collector and drainage systems of the Republic of Uzbekistan are shown in Figure 4 below.

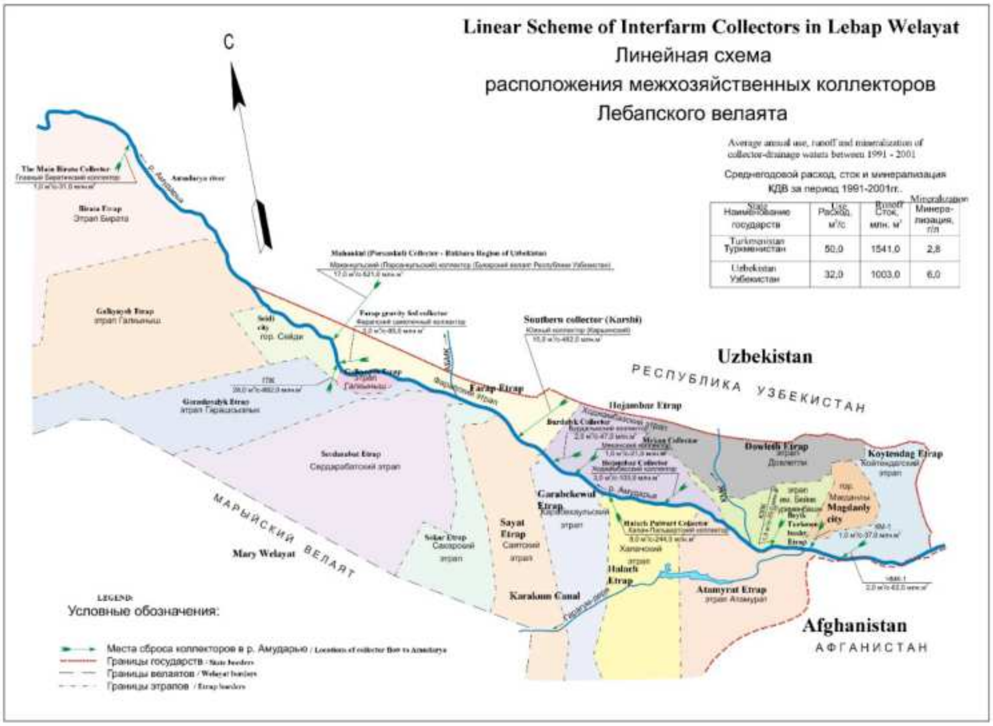


Figure 4. Inter-farm collectors' linear diagram of the Lebap velayat

In Amu Darya Basin, the share of drainage flow from the volume of water for irrigation is in the range of 30-33%. Most of which is diverted outside the irrigated area and is practically lost as a resource. Increase in the river mineralization is also observed (Saparov et al., 2004; FAO, 2016; MWET,2000),

The Amudarya water in terms of content belongs to the category of fresh water with relatively high mineralization. The average salinity at the Atamurat (Kerki) section is 0,5 g/l, but gradually increases downstream mainly due to large drainage discharges, which leads to deterioration of river ecosystem and health problem (Saparov et al., 2004; Gapparov et al. 2011).

To prevent a decline in the socio-economic conditions of local communities, deteriorating infrastructure, modernization and reconstruction of deteriorated irrigation infrastructure, institutional, legal, financial, economic measures to improve water management, capacity building and other policy arrangements shall be implemented.

3.2. Water supply and sanitation – consumers and infrastructure

Most of the country's water supply systems were installed between 1950 and 1980, sewage systems were built mainly in big cities. Furthermore, the development of water supply systems then was mainly aimed at developing new water sources, increasing the capacity of pumping stations. Issues such as the effective development of distribution networks, their zoning and rational distribution of water, increasing the reliability and capacity of main water pipelines, water accounting and many others were practically in the sphere of minor interests and were not included in the operational management and long-term planning of the development of the water sector. This approach was determined by the availability and low cost of electricity. As a result, by 2000, much of the infrastructure was severely deteriorated. The high level of wear required significant capital investment to bring the systems into service, but funding sources were limited. Thus, instead of carrying out planned preventative work, water and utility services organizations were more often forced to engage in emergency restoration work. By the end of 2010, in the country water intake structures included 1200 units, water treatment facilities - 17 units, water pipelines and distribution network - 12600 km with the average age of systems - 30 years. (GWP, 2009; Volovik, 2010; OECD, 2010). Water supply and sanitation services in rural areas are much less accessible than in urban places. Small towns are in the intermediate position. It is a common occurrence that rural residents and small-town residents rely on low-cost groundwater sources, surface water diversions, and protected streams. Even where there is a running water tap, consistent access to high quality services in water use is not always guaranteed. Water consumption by the regions are different (Table 6).

The performance indicators of the water supply and sanitation sector in urban and rural areas are as below:

- Access to improved water supply sources - 97% in urban places;
- Connection to centralized water supply - in cities 85%, in villages 42%;
- Improved sanitation in cities- 99%, in villages – 97%;
- Connection to a centralized sewerage system- in cities 62%, in villages 2%;

Table 6. Fresh water consumption by velayats

Name of velayats	Water consumption, 10^6 m^3				
Ashgabat	Akhal	Balkan	Dashoguz	Lebap	Mary
190	83,5	47,1	23,9	49,1	65,1

The water supply service indicators (Table7) demonstrates high water losses (Volovik, 2010).

Table 7. Some water supply service indicators

Average water consumption per person per day, l/day. person	Duration of water supply, hour/ day		Water loss, %
	City	Village	
323	18	6	75

The urban population's high-quality drinking water supply is satisfactory, while in most rural areas this service remains insufficient. The coverage of the drinking water supply network along the country is incomplete. About 65% receive water 24 hours a day, the remaining consumers are forced to receive water 6-8 hours a day, i.e. in some regions there is a time limitation on water supply. (GWP, 2009; Volovik, 2010; OECD, 2010).

Uninterrupted 24-hour service is provided in big cities. Compared to other regions, in the Caspian Sea coastal areas the drinking water supply is more acute, and in dry years this problem increases even more. In Balkan velayat the own water resources are not enough for the full-scale use of natural resources, the development of industry, agriculture, and the full supply of water to the population for drinking purposes and household needs, significant efforts have been made water supply improvements in recent years. In Turkmen Aral Sea region (Dashoguz velayat) there are also problems in terms of water quality and quantity. In general, there are problems with water losses, ensuring the quality of drinking water, and shortage of material and financial resources for the construction and operation of Vodokanal (organizations within Water Canal) infrastructure (GWP, 2009; Volovik, 2010; OECD, 2010).

Sewage systems in Turkmenistan are available only in big cities. A common type of wastewater disposal is pit toilets. Since the population of rural areas received water from street water taps (pumps), the lack of sewerage did not cause noticeable damage to the sanitary condition of the villages. However, the widespread use of pit latrines by the rural population and disposal of used water directly in the yard remain serious limiting factors in the fight against disease. The volume of wastewater discharged by sewer systems is only about 35% of the volume of water supplied by centralized water supply systems. The installment and coverage of sewerage systems in cities at the beginning of the 2020s was 61,8%, in villages 2% (Volovik, 2010). Like water supply systems, many sewerage systems do not meet modern requirements. Therefore, the development of effective sewerage and sanitation systems is a priority task for the development of the water supply and sewerage complex (GWP, 2009; Volovik, 2010; OECD, 2010; GoT, 2019; GoT, 2023).

According to the water legislation, drinking water supply has the priority among consumers. Sustainable access of the population, especially in rural areas, to safe drinking water has been officially declared a government priority and is consistent with and implemented within the framework of SDG commitments (GoT, 2019; GoT, 2023). Measures to improve water supply were included in the country's national socio-economic development programs for various periods. They set the goal of improving the reliability of water supply and solving the problem of sanitation. In addition, special programs were adopted for the development of the “Avaza” Resort Zone on the coast of the Caspian Sea, as well as the following programs:

“National program of the President of Turkmenistan for the Transformation of Social and Living conditions of the population of villages, towns, etrap Cities and etrap Centers for the Period until 2020”.

-General Program for providing settlements of the country with clean drinking water;

-Program for the development of networks and facilities of water supply and sewerage in Ashgabat for the period until 2050

General Program planned to construct 6871,6 km sewerage network with the total investment 1,338 mld. TMT durinh 2011-2020. During this period the total water pipelines and water network was planned 55643,30 km with the total investments 12,648 mld. TMT. Solving the problems of the water shortage in the Caspian coastal areas is very important for the country. The Balkan velayat’s rapid development due to oil and gas resources since 2010, including the construction of a important resort and touristic zone “Avaza”), led shortage of water resources. In this regard production desalinated water from the Caspian Sea can serve sustainable water supply. To date, ambitious project for the construction of a seawater desalination plant with a capacity of $1,2x10^6$ m^3/day (drinking $1,057535x10^6$ m^3/day and irrigation $0,142765x10^6$ m^3/day) in the urban village of Giyanly, Turkmenbashi district and a seawater desalination plant with a capacity of 200000 m^3/day in Ekerem district to ensure water supply to settlements and land irrigation. The Giyanly plant comprises 5 seawater intake structures located 2,6 km offshore, and 3 outfall pipelines with an average length of 3,5 km, 6 storage tanks (4x 176,206 m^3/unit tanks for drinking water and 2 71,400 m^3/unit tanks for irrigation water. The new plant will become operational by 2028. The estimated cost of the project is 5,43 billion US dollars (TYPSA, 2019; Satymov, 2022).

In practice, full reuse of return water has not yet much developed in the country, although it was included in program documents for the development of water supply and sewerage.

In Turkmenistan, program stages were outlined to achieve the Millennium Goals (MDGs) on water supply and sanitation. By 2015, the goal was to achieve centralized water supply systems coverage 92,7% for urban and 71% - for the rural population. In general, certain advancements are taking place in accordance with the planned course in the direction of the international SDGs indicator on drinking water, relevant work is underway, including the preparation of voluntary country reviews on the implementation of the SDGs. (GWP, 2009; OECD, 2010; Volovik, 2010; GoT, 2023).

3.3. Other water users

In addition to the needs of the population and the agricultural sector, on average, about $1,25x10^9$ m^3 /year are used for production (3%) and energy (4%) needs. This consumption also includes transport, as well as the country’s fuel and energy complex.

In 2022, 982,7 x10^6 m^3 were used for production purposes (SSC of Turkmenistan, 2023). In thermal power, water is a coolant and a working fluid. Thermal power plants use 32-42 m^3/sec to produce one gigawatt of electricity. The Mary State District Power Plant takes water for cooling from the Karakum Canal. The amount of water required to operate thermal power plants depends on their production capacity. Another consumers of water is healthcare, tourism and fisheries.

The unfavorable ecological situation in the middle and especially in the lower reaches of the Amu Darya river is mainly associated with a significant decrease in flow in the lower reaches and in the Aral Sea region. Bacterial contamination of water increases in warmer temperatures and is reflected in an increase in the number of gastrointestinal diseases in the summer. The environmental flow requirement in Amu Darya are 5x10^9 m^3/year at the "Samanbay" site and this has not been observed in recent years (MMWM USSR, 1987; GoT, 1996; Dukhovny, 2002; Dukhovny, 2003; Saparov et al, 2004; Dukovny, 2006; Bogaturov, 2011; Gapparov et al. 2011; Volovik, 2010).

The livestock plays an important role in ensuring food security and social stability in rural regions, providing two-thirds of agricultural products (Aganov et al., 2019; NISSI, 2017; SSC of Turkmenistan, 2022). The pastures account for 38 million ha of the total area of the country, therefore their lands use and water consumption shall be in central attention (Annamukhammedov et al., 2014; Lerman et al., 2012; UNDP 2012, 2; NISSI, 2017; SSC of Turkmenistan, 2023). The share of watering in the total volume of water used together with agricultural water supply is insignificant and amounts to 0,37%. Mitigating these impacts on farms is possible by improving water supply in pasture areas - by building wells, sardobas, water pipelines, and carrying out repair work on existing ones. These measures will contribute to the implementation of SDG 6 and the creation of conditions for sustainable water supply, including drinking water.

3.4. Water depletion trends and water demand forecasting

Turkmenistan is one of the most vulnerable areas to climate change and extreme weather due to its location, geography and historical trends. It is necessary to note the vulnerability of the country due to the steady increase in temperature and increasing water deficit - the highest temperatures and the lowest precipitation levels in the Central Asian region. The main impact of climate change in the Central Asian region, including Turkmenistan, is expected to be a reduction in available renewable water resources. Given the initial limitation of water resources, the expansion of the area of irrigated land, the increase in population and water consumption led to a significant increase in water withdrawal. This situation, especially in dry years, leads to acute water shortages and creates the preconditions for contradictions between areas located in the upper, middle and lower reaches of rivers and canals, between various water consumers of the country, as well as at the transboundary level. The negative consequences of depletion of water resources and deterioration of water quality are manifested in the country, mainly in a sharp drop in the productivity of land and water resources, in the increasing impact of the deteriorating environmental situation on the general economic and social condition, productivity of aquatic ecosystems. Over the past two decades, the country has experienced several hydrological droughts. The situation is characterized by a significant reduction in the water flows of Amu Darya, Murgab, Atrek and Tejen rivers. There is a noticeable reduction in the flows of the Sumbar and Chendir rivers, as well as in other small rivers. A sharp decrease in river water flow was noted in 2000-2001, 2008 and 2011 (Figure 5). In 2013, the annual flow of the Amu Darya amounted to $36{,}1x10^9 m^3$/year.

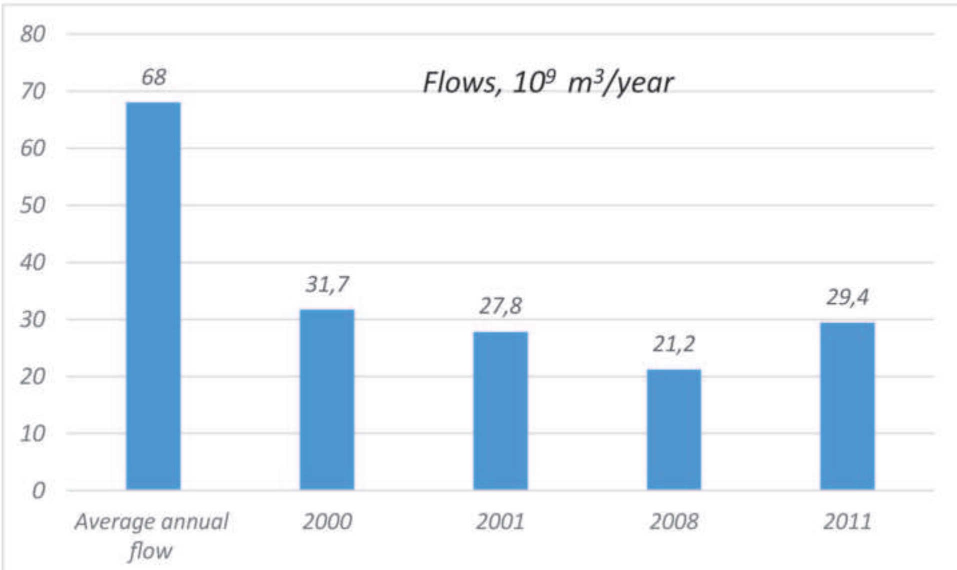


Figure 5. Extreme decrease of Amu Darya water flows

The same trend we can observe in Murgab river, a significant decrease in 2000 and 2008..

According to expert forecasts, the expected reduction in water resources until 2050 in Amu Darya basin is estimaed to be 15%. The flow of Murgab, Tejen and Atrek will decrease by 5-8% by 2030 (Volovik, 2014; Duhowniy et al., 2020; UNDP, 2024).

As a result of the degradation of mountain ecosystems and in connection with the general warming of the planet's climate, the hydrological regime is disrupted, and water resources are depleted. Over the past 40-50 years, the glaciers of the Pamirs have lost more than 25% of their reserves, and this process is developing intensively. It is indicated that in the upper reaches in recent years the rate of reduction of glaciers is 1% per year. The glaciers are melting exponentially and in 10-15 years a sharp reduction in water flow in the Amu Darya River is possible. It is observed decline in the Amu Darya inflow the country in the last two decades. The chronological sequence of the river annual water flows in different years shows that since the beginning of the 2000-th, they are constantly below than long-term average values.

Indeed, 2008 was remembered as an extremely low-water season along the Amu Darya, therefore Central Asian countries reduced by 10% limit for these river from the calculated water demand. Thus, the water flows of Amu Darya River during the crop growing season turned out to be equal to 72,6% of the required level. At the same time, Tajikistan received 93,7% of the required water, but Turkmenistan -74.3%, and Uzbekistan - 64.5% only. At the same time, the water intakes of the lower reaches of the Amu Darya - the Karakalpakstan and the Khorezm region of the Republic of Uzbekistan and the Dashoguz region of Turkmenistan were only 50% supplied from demanded water, which has had a detrimental effect on crop yields. During the drought of 2000-2001, due to a significant shortage of irrigation water, compared to previous years, cotton production in the country decreased by 55,4 0%, the yield in 2002 was only 7 c/ha, while the average for the previous years (1997-2001) had been 15,7 c/ha.

In dry years, high evaporation causes damage not only to agricultural land, but also to small forests and ecosystems. Lowering water levels in rivers requires significant adaptation of settlements, especially those located on the banks of rivers, the Karakum Canal, the Caspian Sea, and large natural and artificial reservoirs.

In Turkmenistan, when developing the First, Second and Third National Communications on Climate Change, several models were used based on methodologies recommended by the Intergovernmental Panel on Climate Change (IPCC): based on these methodologies, specific climate risks for agriculture and water management were identified, including an assessment of climate change in the Third National Communication of Turkmenistan to the UNFCCC. According to future climate assessments, the air temperature in Turkmenistan in 2020–2100 will rise steadily and by the end of the century will increase by 5,35^{0}C (GoT, 1999; GoT, 2009; GoT, 2015; UNDP,2024). On going climate expected to have an impact on droughts (WMO & UNEP, 2008; Allaberdyev, 2014; FOEN, 2009). The increase is projected to be 2C^0 for the country by 2040 - under a scenario with a high level of emissions compared to the base period (1986-2005). And in a high-emissions scenario, climate change will accelerate after 2040, with an increase in average annual temperatures of even up to 6-7°C (by 2100) (Meleshko et al., 2005; SIC ICSD, 2005,1; SIC ICSD, 2005, 2; Allaberdyev, 2014; UNDP, 2024; Shpakov, 2010). As per the diagrams in Figure 6, precipitation will increase slightly, but over a longer period a significant decrease is expected (SIC ICSD, 2005, 1). Also, several studies by international research centers indicate a high degree of vulnerability of the country. Thus, according to the special ND-GAIN index proposed by the University of Notre Dame from the USA in 2023, Turkmenistan took 117 place among 185 countries with the index 44,2. The shortage of water resources compared to the current level according to an aggregated estimate forecasted to 5,5x10^9 m^3/year. This is equivalent to approximately 20% of current water use in the country agricultural sector (Turkmensuvilymtaslama, 2007; Sokolov, 2023). Under each scenario, it is expected that climate change will directly or indirectly affect livelihoods, create health threats, change the lifestyle of the population, and increase climate migration. Due to a decrease in water availability, coupled with an increase in land degradation, there will be an impact on pastures and crop production, a decrease in agricultural productivity and food availability, damage to reservoirs and irrigation systems, and economic losses. Agriculture is at particular risk, losses in which from 2016 to 2030 could amount to 20,5 billion USD (OECD, 2016).

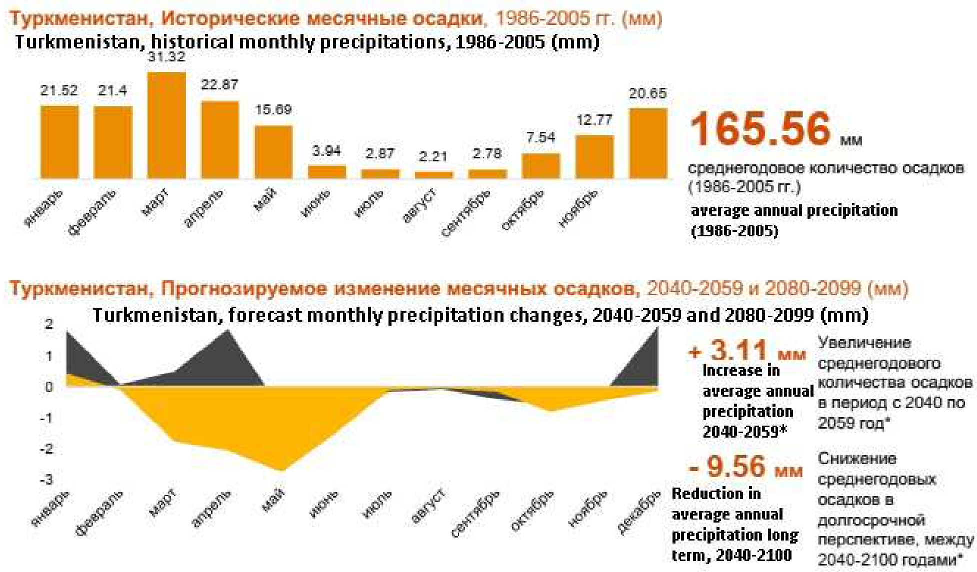


Fig. 6. Changes in precipitation patterns in the short and long term

Rising global and regional temperatures will lead to changes in the hydrological cycle in Central Asia, including Turkmenistan. More specifically, water supplies will decrease due to rising temperatures, the impact of accelerated glacier melting, and decreased precipitation, which will consequently lead to a significant decline in water availability by 10-15% after 2050. The situation with glaciers will continue to deteriorate, eventually they will no longer serve as a reliable storage system, and summer water resources will depend only on snowfall from the previous winter. Also, water quality is declining because of the intensification of the hydrological cycle and anthropogenic factors (Chembarisov, 1989; Saparov et al., 2004; Yablokov, 2006; Volovik, 2010; Gapparov et al., 2011; Sokolov, 2023). Resent data on the Amu Darya River flow show systematically low water levels in the river and demonstrates increasing limit use (Table 8).

Table 7. Amu Darya river water flow and usage

Year	2018	2019	2020	2021
Water volume, %	71	93	78	79
Limit use, %	80	98	89	85

In other rivers of the country, low water levels are also observed, especially during growing seasons. In Figure 7 the status and forecast for these rivers is given (UNDP, 2024).

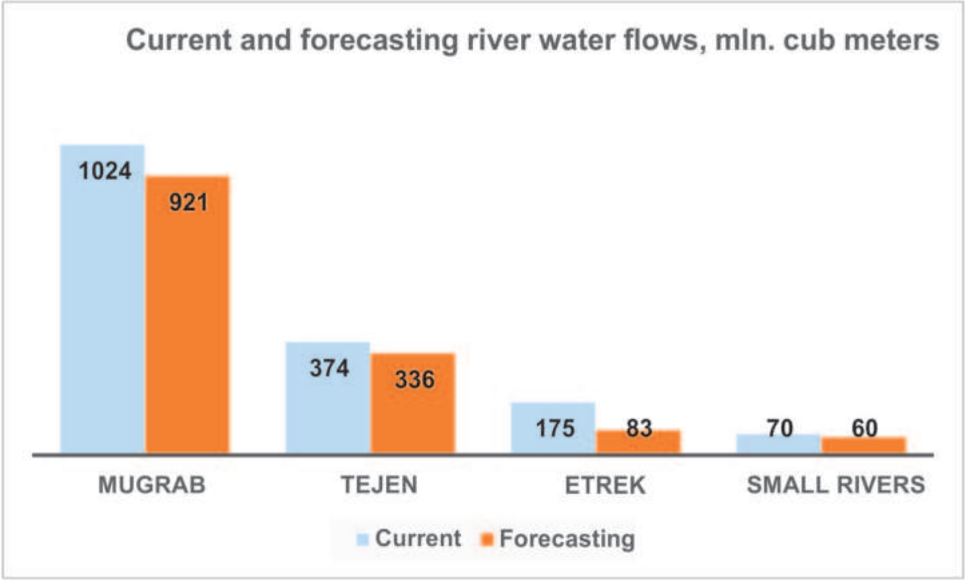


Figure 7. Current and forecasting river flows in Turkmenistan

In Amu Darya basin the most critical situation is in the lower reaches of the river. This situation is most acute in dry years. At the same time, there is uneven water distribution within the lower reaches of the river.

The water withdrawal limits for the basin states are set by the ICWC for growing and non-growing seasons. If the actual water content of the river is lower than the calculated one, a proportional reduction in water intake limits is carried out throughout the river basin. This scheme makes it possible to regulate relations between states on joint management of water resources in the Amudarya river basin. However, as practice shows, it is not possible to adjust the limits accordingly, as a result of which the deficit in the lower reaches of the river is further aggravated. In many cases, water deficit reaches such proportions that it inevitably leads to plant stress and a significant reduction in yield.

It is necessary to consider the increasing water intake primarily by Afghanistan due to construction of Kosh-tepa canal (Dukovny et al., 2020; UNDP, 2024).

In Etrek River basin in Western Turkmenistan there are about 20000 ha agricultural land, but river water could irrigate only 25% before the latest manifestations of climate change and currently water availability indicators have become even lower.

Climate warming will become an additional risk factor for the development of hydrological drought and desertification, negatively affecting water resources and, accordingly, agriculture, therefore attention must be paid to the early warning of the likelihood of critical events. This will reduce the negative impact and allow to take timely measures in low water conditions periods.

The limits of the Amu Darya basin are established between the basin countries, according to the level of complete depletion of water resources, based on irrigated areas and specific water consumption. It is noted that further development of irrigation is allowed within established limits by reducing specific water consumption through rationalization of water use.

Turkmenistan carries out measures to conserve water resources, not at the transboundary, but mainly at the national level, saving water allocated under quotas from transboundary sources and local resources by reconstructing irrigation systems and reducing water losses, introducing advanced technologies in irrigation, optimization of the composition and placement of agricultural crops and others.

The most significant factors in the growth of demand for water resources will be demographic increase, growth in industrial production, technological costs for flow regulation, and also the increase in the needs of Afghanistan (Dukovny et al., 2020). Turkmenistan, like most countries in the Central Asian region, aims at industrial and agricultural development. The SIC of the ICWC made prognosis on population forecast in the Central Asian countries, according to which the population of Turkmenistan by 2045 will be expected to be 7,7 million inhabitants (Dukovny et al., 2020).

Agriculture is particularly at risk, with losses of 20,5 billion USD from 2016 to 2030 (World Bank, 2019). Thus, future demand in agriculture, industry, drinking water and other sectors will depend on the country's arrangements to optimize water consumption by upgrading existing water infrastructure to reduce unproductive water losses, introducing new technologies aimed at better water management, water reuse, water users' attitude towards water resources consumption and protection, updated environmental policies in the context of climate change and implementing mitigation and adaptation measures to strengthen the country's resilience to the effects of rising temperatures and declining water resources.

CHAPTER 4. WATER TARIFFS AND INVESTMENTS

4.1. Public investment

Adequate financing of water resource management in Turkmenistan important to reduce uncertainty and manage risks, especially in terms of emerging climate change. The infrastructure of the agro-industrial complex mainly is concentrated on irrigated lands, including irrigation facilities. In the country water resources use and management costs are financed by the public budget finances at the regional and national levels - they are included in state strategies, programs and plans for the development of the agro-industrial complex (NEAP, 2002; GoT,2011,1; GoT, 2011,2; GoT, 2014; GoT,2015). At the district level, financing is provided from the state budget and payment for irrigation services.

The country mainly finances construction, modernization and reconstruction of infrastructure. Performs O&M works, including repair of infrastructure, restoration of the river/canal bed, preventing overgrowth of weeds and siltation and sediment control to maintain the infrastructure of water management organizations and other water related activities.

To adapt to the consequences of climate change and ensure food security, changes in the country's financial policy are required to ensure adequate priority provision of investments in the water sector. The choice of directions and volumes of investment should be determined by an analysis of current costs and the effectiveness of measures.

The financing of water sector related activities in the country provides maintaining the infrastructure at a relatively stable condition, but insufficient level. Even with government support, financing infrastructure modernization by water management organizations is not an easy issue. There is need to attract additional financial resources, including grants and loans. During the period 2020-2025, government contribution is provided both for maintaining water infrastructure and improving water use, and for reducing salinization of irrigated lands in five velayats. Capital investments in the amount of 22,7 million USS are planned to improve the melioration condition of irrigated lands in the Dashoguz velayat, whose lands are most susceptible to salinization. In Lebap velayat, located upstream of the Amu Darya, the planned finance for land reclamation is 9,8 million. In the state seven-year plan (2019-2025), there are investment plans by year across the country and regions for maintaining the technical condition of water infrastructure.

National program documents regarding plans in the water sector provide for the construction of large and small reservoirs, increasing the capacity of existing large reservoirs, repairing existing and constructing new irrigation and drainage canals, as well as ensuring careful use of irrigation water. Thus, regarding the involvement of investments in water conservation, in accordance with the developed National Program, by 2030, drip irrigation will be applied on 260000 ha and sprinkling systems will be used on 219000 ha of area (GoT, 2011,1; GoT, 2014). In terms of planned state expenditures for the coming period, the growth of investments in the "Program of the President of Turkmenistan for the Socio-economic Development of the Country for 2019-2025" is significantly reflected and in more detail in the "Program for the Development of the Agro-Industrial Complex for 2019-2025." In total, capital investments in the agricultural sector are planned in the amount of 6,8 billion TMT, with their growth in 2025 to be 4,7 times higher compared to 2019 (GoT, 2019).

Turkmenistan annually allocates significant financial resources for the implementation of new large-scale projects for the construction of centralized water supply and sewerage systems, to improve the reliability of water supply to the population and solve the problem of sanitation. The country's socio-economic development programs for various periods, special programs for the development of individual cities (Ashgabat and others) and regions ("Avaza" Resort Zone on the Caspian Sea coast and others) provide for investments in measures to improve national water supply. Until recent years, the operating expenses of the country's water and communal services were fully subsidized by the state in terms of providing water supply services to the population, currently, after the reforms, this situation has improved somewhat (GoT, 2011, 1; GoT, 2011, 2).In addition within the adopted programs water management works will be carried out at the expense of state and local budgets, including hydraulic structures , irrigated lands, water bodies , rural water supply systems, construction and repair, grade (field leveling), bank protection, and other works.

Taking into account the trend of decreasing water resources, it is necessary to note the importance of investments in the modernization of the water sector of Turkmenistan. It is known that the speed of improvement or reorganization of the water resources management system is limited by the volume of investments in the water sector, which, ultimately, is determined by the state of the country's economy as a whole. It is necessary to reconsider funding priorities in favor of the water industry and improvement of the efficiency of investment allocation. The right approach is when modern water management and, accordingly, finances are aimed at meeting the needs of today's water users while using the best available resources and technologies.

The reasonably allocated investments are needed to improve man-made and natural infrastructures for the creation of storage, transportation and purification of water. Investment is required to be made for the establishment of easy accessible and reliable information base, as well as towards stronger and more flexible institutions. In this regard investments are required for improvement of institutional, personnel, cognitive potential, rational strategic planning, O&M and other long-term institutional support costs.

It is necessary to attract domestic and international investment in the water sector. Attracting investors to agricultural water supply issues will significantly accelerate reform of the rural water supply sector. When planning investments to implement technologies, consideration should be given to whether they will lead to significant, practical water savings. It is necessary that donors and investors be involved in such work at the earliest stages of program development. This will ensure that future projects comply with the goals and programs, including government bodies and international financial institutions.

Regarding the implementation of activities under "ASBP-4" (Aral Sea Basin Program-4), carried out within the framework of IFAS, including with the contribution of Turkmenistan, their priorities are represented by activities in 4 areas. This includes projects dedicated to the modernization and reconstruction of existing water management structures for irrigation purposes, assessing the impact of siltation of Central Asian reservoirs on the efficiency of flow regulation, improving the reclamation condition of lands in the Amu Darya basin, improving systems for accounting and monitoring water resources in this basin, reconstruction and improvement of technical condition in interstate reclamation facilities, increasing the capacity and strengthening the material and technical basis of national water management organizations, joint actions to adapt to climate change in the water sector, conservation and restoration of ecosystems in the Amu Darya basin, dissemination of the best climate-adapted practices, organization of systemic forest plantings in the Aral Sea region, ensuring access to drinking water and sanitation.

4.2. Public-private partnership initiatives

Until very recent years in Turkmenistan, the participation of the private sector in the water supply and sewerage segment was limited. A major achievement can be considered a significant expansion of the possibility of participation of business structures in the water supply sector in accordance with the Law "On Drinking water" (GoT, 2023). In general, private sector participation is limited to participation in the construction and repair of water supply systems, as well as in the production of bottled drinking water. It is obvious that tariffs are significantly lower than the actual costs of water supply and water treatment (GWP, 2009; Volovik, 2010; OECD, 2010). In the context of providing drinking water to the population, the main reason for introducing this practice was to ease the financial burden of the population to pay for the relevant services (GWP, 2006; Volovik, 2010; OECD, 2010; GoT, 2023). Since this approach weakly stimulates the development of financial sustainability of organizations involved in water supply, today there is no serious interest of private business representatives to invest in the development of these systems (Volovik, 2010; GWP, 2006). Such interest can appear only after the development and implementation of more modern economic instruments and financial mechanism (OECD, 2010; Pohl et al., 2017).

Recently, most water users have become privately owned, including due to the ongoing policy of reducing farmer associations and increasing farms (farmers) and other forms of non-state ownership. At the same time, the productivity of peasant farms is low, and the price of agricultural crops under state orders, set administratively, is lower than market prices. Therefore, the financial assessments of agricultural farms are low.

Many innovations and initiatives depend on external financing. It is also necessary to increase the solvency of farmers for water supply services, since with low incomes, it is obvious that water users will not be able to become a promising source of financing for the costs of operation and maintenance of the irrigation system. External sources are not suitable for permanent financing of operation and maintenance costs, but they could be important sources of financing, for example, for the provision of equipment for operation, maintenance and building human and institutional capacity. Funding options may be expanded and regrouped to consider additional resources arising from the joint implementation of certain activities in projects with international participation implemented in the country, as well as from other donors.

Regarding the involvement of the private sector in the ownership, the Water Code allows for the transfer of on-farm facilities and artificial water systems into ownership and use or into the property. Objects of natural origin can only be transferred for use, as their privatization and purchase and sale are prohibited (GoT, 2023). The lack of a certain income among water users-farmers, sufficient to fully cover the costs of operation and maintenance of hydraulic structures, minor repairs and improvement of their plots, as well as the acquisition of water-saving technologies, is one of the main obstacles to their participation in the improvement of water infrastructure (Khosrt, 2002; GWP, 2006).

Almost all their financing comes from the state budget and only a small part from own funds, and almost no investment is made by the private sector. Therefore, in order to enhance the participation of the private sector in the field of water and land resources of Turkmenistan, it is important to reconsider and improve land and water legislation, search for non-state and non-capital means of improving the country's water sector through organizational and public forms of participation, including the development of public-private partnerships in the agricultural and water sectors.

Most investments from entrepreneurs are allocated for drip irrigation in greenhouses. There is some interest also in private sector investment for the purchase and installation of sprinkler systems in the velayats. In recent years, the country has been undergoing a process of transferring land for agricultural purposes for up to 99 years. Among those land obtainers, private entrepreneurs are ready to make investments to introduce innovative and efficient irrigation technologies and methods of improved agriculture on their fields. Therefore, it is necessary to support those farmers, on whose irrigated lands the promotion of improved technologies is planned. Along with the state, it is necessary to involve the Union of Industrialists and Entrepreneurs of Turkmenistan and the country's banks in carrying out these measures. Most financially strong farmer-entrepreneurs are members of this union, and this Union has the appropriate potential. Along with existing preferential lending, it can be supported by providing other forms of incentives, preferences, consultations, and the adoption of simplified legal and institutional rules for the active involvement of the private sector in irrigation activities.

Covering the gap between the costs of "Vodokanal" (Water Canal) enterprises and revenues from tariffs remains an almost constant problem. And the almost shortage of financial resources makes it difficult to carry out routine repairs and maintenance of water and sewerage equipment, as the pumping and other technical devices are highly susceptible to wear and tear, infrastructure reconstruction is required. Accordingly, significant subsidies are allocated for this, which is a burden on the state budget. Among those that gave a relative positive effect, we can mention the introduction of payment for the drinking water consumed, albeit low, although before there were applied free water use system. Reforms were launched in this area with the transition to the water accounting system and subsequently payment for water supply services.

Multilateral financing mechanisms established under the UN Framework Convention on Climate Change, the Global Environment Facility, the Adaptation Fund and other funds, organizations and agencies are important in attracting the capital investments needed to achieve goals.

4.3. Water tariffs and public policy

Revenues to the water sector for irrigation and water supply mainly consist of fees for irrigation services, drinking water and sewerage, as well as fines for water discharges and others.

The established price for drinking water in the country is 0,5 TMT/m^3, which can be considered acceptable and affordable for most of the population. With the introduction of a fee for consumed water for the population, meters were installed at the same time, which should be recognized as another positive policy in ongoing water accounting reform.

As for the paid water use system, one of the sources of financing in the water sector is the payment for irrigation services to suppliers. There are also small revenues from penalties imposed by the water resources control service. For various reasons, this tool does not work well yet: a vicious circle has formed, when the low level of collection of fees for irrigation services is due to the low quality of water supply. And the low quality of water supply is due to the faulty condition of the irrigation infrastructure. In addition, a significant portion of farmers have difficulty in generating income from their agricultural activities. Since 1994, a two-stage tariff has been in effect in the water sector. If the fixed consumption rate is exceeded, the water consumer pays a higher price than the previously established nominal price. Until recently, the payment system had a provision on a differentiated approach to determining tariffs for water supply services - tariff rates for water supply services can be set for different categories of water users (GoT, 2023). Currently, a per-hectare tariff for water supply is applied, considering the water needs of various agricultural crops. The cost per one cub meter is indicated in an annual government regulatory act, which usually approved by the head of the water department. The tariff indicator per unit of irrigation water volume is indicated under the heading "Cost of water supply services to all water users growing agricultural crops". This value is 0,0298 TMT/m^3. Further, depending on the crop type, irrigation rate, water costs for per ha is calculated by multiplying the cost of water supply services in 0,0298 TMT by the irrigation norm of a specific crop required for 1 ha. In establishing irrigation norms is used before approved guide "Irrigation regimes for agricultural crops of the Turkmen SSR" Therefore the irrigation water tariffs are different depending on the crops (Table 8).

Table 8. Calculated irrigation water tariffs for main agricultural crops

Crop name	Cotton	Wheat	Rice	Forage crops	Fruit	Vegetables	Melons
Irrigation water tariffs, TMT/ha	208,6	157,9	894,0	241,4	253,3	376,5	157,9

According to government decisions, until recently, 50% to 70% of the costs were subsidized by the state. The main reason for this practice was the country's policy to ease the financial burden of providing farmers with irrigation water.

CHAPTER 5. FUTURE WATER MANAGEMENT

5.1. Water demand of various consumers

The state of Turkmenistan's water resources is largely defined by anthropogenic factors and climate challenges. This vulnerability is largely associated with the increase, frequency and intensity of extreme hydrometeorological events such as drought, hail, storm winds, frosts, and heat waves. It is also associated, though to less extent, with floods and mudflows, mainly in the mountainous regions of Turkmenistan.

All sectors have a need for water resources. The agricultural sector particularly stands out in this regard, as this sector consumes the majority of the country's water resources. In this regard, irrigated agriculture stands out to the greatest extent. In livestock it is consumed to a much lesser extent, but the need to provide water for livestock is also in high demand. In the arid climate of Turkmenistan, agricultural production is inseparable from water management. More than 95% of agriculture is based on artificial irrigation of currently irrigated area, which is 1,75x10^6 ha (NISSI, 2019; SSC of Turkmenistan,2022). The rising of temperatures and relative air humidity increases leads to an increase in irrigation rates of the agricultural crops and water consumption by plants (Table 9). Depending on the crop type the increase in irrigation rates during the periods of 1961-1985 and 1986- 2915 is varying from 100 to 600 m^3/ha (UNDP, 2024).

Table 9. Changes in annual crop irrigation norms due to climate change

No	Changes in annual irrigation norms of agricultural crops, between 1961-1985 and 1986-2015, m^3/ha							
	Cereals	Cotton	Corn	Potato	Melons	Alfalfa	Fruit	Vineyard
I	**Kopetdag irrigated zone**							
	-500	600	400	500	900	600	500	0
II	**Murgap-Tejen irrigated zone**							
	-500	400	400	400	200	500	400	0
III	**Middle Amudarya irrigated zone**							
	-300	400	500	100	400	500	100	100
IV	**Lower Amudarya irrigated zone**							
	0	500	500	600	500	700	200	400

The agricultural sector of the country employs about half of the population and plays a significant role in food security, cotton and textile production. It is planned to increase the irrigated area to 2 million hectares by 2030 (GMT, 2022). And accordingly there will be an increase in the need for irrigation water. The irrigation rate of cotton (net rate) by 1750 m3/ha higher than that of grains. There is a high probability of growth in cotton crops in the country with about half of the country's irrigated land. Accordingly, irrigation water demand will increase, in addition considering the inevitable big water losses in transportation through canals and directly in the fields during the irrigation.

Drip irrigation has become relatively widespread. But this development is primarily the case in forest plantations that have undergone massive development in the last two decades in areas adjacent to the city of Ashgabat and the regional and district centers. Annually 3 million seedlings of various types of trees are sown in the country. The small local plots and greenhouse farms also apply drip irrigation, the industrial implementation of drip irrigation in the agricultural sector is necessary for water saving. Sprinkling irrigation technology has become most widespread, and applied in in Ahal (1650 ha), Dashoguz (695 ha) and Balkan (138 ha) velayats. Most of all, sprinkling is used for irrigating wheat - on 1910 ha. Also, alfalfa (lucerne), corn, cotton and barley are irrigated using this method - a total of 572 ha. Currently, the areas with sprinkling irrigation have increased, including those used in Lebap velayat.

After gaining independence, several cotton processing and textile enterprises were financed and built on a large scale in the country. Therefore, the reliability of water supply in irrigation is very important not only for food security, but also for the cotton growing and processing. An increase in water demand due to the development of food processing and production in other segments of the industrial sector also is expected. The tourism water demand increase has already taken place over the past decade, including the ongoing large-scale construction and development of the Avaza National Tourist Zone on the Caspian coast, where water supply is mainly provided through the built desalination plants.

The situation is becoming even more aggravated due to the interweaving of regional and national aspects in Central Asia, with the high transboundary nature of Turkmenistan's water resources, and the need to meet requirements forward to protect natural complexes (NEAP, 2002; GoT, 2006; GWP CAC, 2006; Saparov, 2007; Bekniyaz et al., 2018). In accordance with the average water intake limits for the period 1992-2016 sanitary and environmental releases during the non-growing season in the lower reaches of rivers totaled $0{,}8x10^9$ m^3 across the countries of the Amu Darya basin, and the supply of river water to the Aral Sea region and the Aral Sea was $4{,}2x10^9$ m^3, altough the environmental norm is $5\ x10^9$ m^3 /year (Ashirbekov & Zonn, 2003; Bekniyaz et al., 2018). Over the past many years, several Central Asian countries, including Turkmenistan, have not been complying with the contractual conditions for ensuring environmental and other releases to the lower reaches, including the Amu Darya river.

The current situation is characterized by growing demands for water resources and the increasing impacts of climate change on water management organizations at all levels - national, regional and local. Based on global experience in the use of water resources, the country requires a radical improvement in the structure of their use. Reduction of water use in irrigation is required. The worsening situation with water resources due to ill-conceived activities dating back to Soviet times has a negative impact on the water infrastructure itself.

The further growth of the country's population is expected, which poses a challenge to food security and water resources. Further growth in consumption, development of agricultural production, processing industry, urbanization of territories, future growth in water needs and, accordingly, an increase in water intake in the upper reaches of transboundary rivers complicates the task of fully meeting these needs.

5.2. Adaptation measures for the protection and rational use of water resources

The issue of rational use and conservation of water resources in Turkmenistan becomes an important aspect of sustainable development. The country uses only about 10% of the land suitable for irrigation and that currently the available water is fully used. Increasing the productivity of water used, primarily in irrigation, is the most important task. To achieve this, obtaining additional water reserves requires a comprehensive strategy. This dictates the need to carry out a set of preventive and other adaptation measures that will make it possible to compensate for the shortage of water resources expected due to climate change.

In 2021, the "Institutional Analysis of the Existing National System and Processes Related to Climate Change in Turkmenistan" was published. The document states that Turkmenistan already has four key enabling factors facilitating the integration of adaptation at all levels (vertically) and across all sectors (horizontally): (a) high-level political support, (b) dissemination of information, (c) capacity building, (d) provision of financial resources (Mislimshoeva B. et al., 2021; UNDP, 2024). Under the current situation, a clear prioritization of water use areas, development and implementation of construction and operational measures to increase water use productivity in all sectors and areas of water use, ensuring uniform water supply through irrigation systems and canals is an urgent need. The water problem is most closely related to irrigation and therefore the bulk of improvement measures should be concentrated there. Implementation of improvement measures in the irrigation sector will simultaneously significantly solve the problems of rural water supply and pasture watering. Adaptation measures should be aimed at achieving an increase in water productivity and obtaining additional reserves of irrigation water by reducing losses. In most irrigation systems it would be advisable to carry out replacement, rather than repair of technical devices and equipment.

An important direction for increasing the productivity of irrigation water is to improve its distribution on the agricultural field by improving irrigation techniques and using water-saving technologies. Under the natural and climatic conditions of the country, sprinkling irrigation is most appropriate for irrigating grain, vegetable and fodder crops, as compared to surface irrigation, 35% less water is consumed. Today, less than 1% of irrigated land uses water-saving irrigation technologies using sprinkling and drip irrigation. Simplified drip systems are used on large areas of forest. Meanwhile, late state programs provide for and are already carrying out design work to re-equip significant areas for irrigation in the velayats of the country. Thus, for 2019-2025, drip irrigation is planned to be installed in 600 ha area in Lebap and more in Dashoguz velayats.

The traditional surface irrigation method will remain predominant in the near future, therefore, it is important to disseminate simple, affordable, low-cost water-saving technologies for surface irrigation, including i) carrying out the 1-st and 2-nd growing season furrow irrigation of cotton by reduction 20% of water; ii) irrigation along short blunt furrows and double-sided irrigation on low-slope and non-slope lands; iii) discrete watering; application of polyethylene coverings to reduce evaporation; iv) rice irrigation without constant flooding and sowing seedlings. An important adaptation technique for furrow irrigation is the selection of optimal sizes of irrigation techniques elements such as area of irrigation maps, length of irrigation furrows, amount of flow into the irrigation furrow, number of simultaneously watered furrows, width of row spacing and irrigation strip, etc.), intra-brigade water rotation, organization of round-the-clock work of irrigators, stopping end discharges or fully using end discharges in the underlying areas.

An effective measure is laser leveling the field surface. This important reclamation type of work is used on cultivated areas, although not on a wide enough scale. Since when carrying out irrigation in most cases, good leveling of a field makes it possible to use water significantly more economically and achieve uniform and high-quality irrigation, while also significantly facilitating the work of the irrigator. There are also significant benefits in agrotechnical and other aspects when growing crops.

An effective measure of water conservation at the lower level of water resource management is an organized review of water distribution during drought, which should include adjusted on-farm water use plans. Among adaptation measures, new technological methods should be considered in irrigated agriculture, aimed at reducing freshwater withdrawal from sources and eliminating return water discharges. Among the proposed joint adaptation measures can be noted regulation of water demand, optimization of the crop pattern by areas, concentration of agriculture on lands with the best fertility and reduction of irrigated agriculture on marginal lands and areas too remote from the source of irrigation.

Among the possible ways to achieve lower water consumption is restrictions on the cultivation of water-intensive crops such as rice, cotton and incentive mechanisms for the efficient use of water (Khosrt, 2002). At present the decision to change crop composition depends not depends on farmers, as such an action is impossible without the government bodyes and specialists.

One of the ways to solve the water problem is also to develop a water reuse system. Since huge volume drainage water accumulates in the country, it is important to introduce reverse osmosis and progressive methods of desalting drainage water while complying with environmental standards.

Introduction of progressive irrigation methods will allow saving 25-30% of irrigation water. The adaptation measures shall include improving the technical condition of irrigation systems, construction of reservoirs and reconstruction of hydraulic structures; updating of legal framework of water sector; introduction of precise water accounting system through digital solutions and technologies, enlargement of land reclamation.

There is certain positive changes in the regional specialization of agriculture in the western part- Balkan velayat and the north of the country -Dashoguz velayat. The decision taken at the state level to stop cultivating cotton in the Balkan velayat since 2014 due to low production efficiency and problems with irrigation water. One can point out a significant reduction in areas under rice in Dashogzu velayat due to water shortage. A redistribution of these crops was carried out in Lebap velayat. In general, due to the high-water demand for rice cultivation, the area under rice cultivation has decreased in recent years. Currently the rice growing area is approximately 18000 ha, of which 8100 ha are sown on the lands of Dashoguz velayat and the rest of approximately 10000 ha – in several etraps of the Lebap velayat.

This is important to revise water tariffs in water supply and encourage water conservation for farmers. According to existing regulations rural producers can enjoy from preferential loan for the purchase of agricultural machinery and water-saving equipment for a period of 10 years with the condition of annual repayment in equal shares, based on the operating period with an annual rate of 1%. Identification and development of additional water sources is the most important component of overcoming the consequences of low water supply and drought. There are currently two more reservoirs with a total design capacity of 1450 million m3 under construction.

The return flow, which, together with transit drainage waters from Uzbekistan, exceeds $10x10^9$ m^3/year should be considered as a source for irrigation of salt-tolerant crops on light soils and watering of desert pastures, as well as for irrigation after desalination or mixing with fresh water. In the Kopetdag zone of the Ahal velayat, drainage water with an average annual mineralization of 2,6 g/l can be used for crop irrigation. On irrigated lands located on the left bank of the Amu Darya River in Lebap velayat, irrigation with drainage water is allowed. There, the annual permissible average mineralization of drainage water is 2,4 g/l. In Dashoguz velayat, it is possible to use drainage water for crop irrigation by mixing it with water from the Amu Darya River in a one-to-one ratio. In the Murgap oasis, Mary velayat, it is possible to use drainage water with average mineralization 6.46 g/l, by mixing it with water from the Karakum Canal in a ratio of one to three (MWET, 2000).

Basically, only a small amount of drainage runoff was used for irrigation needs (about 1% of the drainage runoff), which increases during low water periods (Gapparov et al., 2011). The accumulated return water, reuse of wastewater for irrigation and livestock to meet domestic and technical needs shall be considered for wide use in the country. The use of drainage water with average mineralization 3- 18 g/l from Turkmen Lake is also is advisable to be used.

Groundwater of non-potable quality with the minimum degree of treatment can be used as an additional source of water supply.

Taking into account the real situation in climate changes the recommended adaptation measures are summarized in Table 10. (UNDP, 2024).

Table 10. Climate change and proposed adaptation measures for surface water resources

Impact of climate change	Proposed adaptation measures
Decrease in annual flow	Use of water-saving technologies at all levels of irrigation systems
	Application of a complete water circulation system in industrial production and energy sectors
	Application of new technologies for the reuse of waste and collector-drainage waters
Changes in hydrological regime (flow distribution) throughout the year	Construction of the new reservoirs for flow seasonal regulation
Changes in the hydrological regime (flow distribution) in different years	Construction of the new reservoirs for long-term regulation
Increase in the number of floods, high water and mudflows	Carrying out bank protection works
Increased frequency of ice events	Carrying out operational (anti-ice) measures

5.3. Strategic plans and initiatives for better water management

Adaptation measures should be reflected in long-term national strategies, plans and programs for the country's development, drawn up considering scenario planning methods. Strengthening water management institutions in arid environments is key to effective adaptation. The urgent measures require upgrading of hydrometeorology system, including preparation of specialists for hydrological forecasting, supply with the necessary equipment and technical means. Implementation of a more reliable Early Warning System to ensure timely response to emergency situations is also required action. It is important to develop incentive mechanisms to attract more qualified professionals to the water sector.

It is important to raise public awareness, increase the education of the population in matters of water supply and sanitation, involve the public in the process of making management decisions, form a careful attitude towards water (behavior change) for various types of water use and the provision of appropriate services. It is important to develop a network of information and consulting services and other forms for the dissemination of relevant knowledge, regulatory and legislative acts, information on water-saving irrigation technologies, new drought-resistant varieties of crops and others. Improvements in providing early warning systems and accurate weather forecasts to remote areas will allow people to be better prepared for challenges.

In this context, the Government of Turkmenistan has made an initiative to create a Regional Center for Technologies related to Climate Change in Ashkabad during the 3rd World Conference on Disaster Risk Reduction, held in March 2015. The initiative is to create a specialized structure under the auspices of the UN - the Regional Center for Technologies Related to Climate Change in Central Asia. It is expected that the Center will undertake the collection, synthesis, processing of data, identification of the occurrence of droughts, low water and other phenomena and transmission of messages to the authorized body, as well as normative and methodological activities for the development of criteria and assessment of drought risk both at the national and regional levels under the currently emerging modern conditions.

The attention should be paid to increasing soil fertility and the efficiency of use of irrigated land. In this regard, the following tasks are solved:

– introduction of scientifically based farming systems with the combination of agrotechnical and agrochemical measures;

– improving the structure of arable land, taking into account the prospects for the development of sectors/branches and the need for animal husbandry for feed;

– development of crop rotations that are optimal for arid conditions in crop farms of all forms of ownership with active cooperation of land users of all categories;

– improving the reclamation condition of irrigated lands by increasing the capacity and efficiency of irrigation networks, taking into account the regulatory requirements for drainage networks;

Promoting Integrated Water Resources Management (IWRM) is an important adaptation measure. It aims to coordinate water resources across all relevant sectors, policies and institutions to achieve national water and food security. Such management requires parallel consideration of different water use options.

Improving the legal regulation of the activities of organizational structures in the water sector necessitates improving the national legislative and regulatory framework for the activities of the State Committee for Water Resources, including the development and adoption of by-laws. To minimize conflict situations between management bodies and water users, it is necessary to continue legal work to bring the content of regulatory documentation to legislative norms. In parallel with economic incentives and other financial levers, legislation may provide for a simplified repurposing of land use, the use of arable land for pastures or forest planting, or its allocation for other purposes.

CHAPTER 6. CONCLUSION AND RECOMMENDATIONS

6.1. Addressing the challenges of water resources under the climate change

An analysis of the water sector in Turkmenistan demonstrates the relevance of taking targeted measures and efforts to rationally use limited water resources and protect them as the main source of the country's well-being. In this point regional cooperation and integrated approaches are critical to mitigate the impact of uneven water distribution, water scarcity and climate change on the sustainable development of the country. Comprehensive strategies need to be implemented, including continued policies on effective water management, sustainable agricultural practices and the development of climate-resilient infrastructure. Smart solutions shall be widely applied for precise water management and unproductive loss elimination. Development of human resources and changing the attitude of water users towards water also is key elements of improved water management.

Over the period of seven decades since 1950, climate warming in Turkmenistan has manifested itself at a faster pace than in other parts of the world on average. According to weather observations for 1992-2015 one can note an increase in temperature of 1,4°C over 55 years. The negative consequences of this trend can be seen from the decision of the IFAS in 2000-2001 and in 2007-2008 to set a 10% reduced consumption of the Amu Darya water. During above mentioned year, the water of the Amu Darya River was equal to 72,6% in crop growing period and as a result, Turkmenistan received only 74,3% from the allowed water intake.

The predicted increase in temperature and gradual decrease in Amu Darya River flow will have a negative effect which is estimated 10-15%. During the growing season the flow will reduce and the need to increase irrigation norm will arise against the backdrop of a decrease in the limits of water, used for irrigation needs. Water shortages and subsequent losses in agricultural production during dry periods of low water will cause potentially serious socio-economic consequences, there is a high threat of loss of ecosystem integrity in the area adjacent to the Aral Sea. The result of a decrease in the quality of water in the Amu Darya will be a deterioration in drinking water supply, which leads to an aggravation of the sanitary and epidemiological situation and an increase in morbidity, and in general, the degradation of living conditions and increased migration of the local population.

None of the climate scenarios constructed in accordance with the IPCC methodology indicate an increase in water resources in the region in the future. Therefore, Turkmenistan will become one of the most vulnerable among Central Asian countries.

The recommended policy measures are common for the arid countries with the water shortage, which includes i)improve the organizational structure of water resources management, water-related industrial and social relations; ii) traditional technical measures for water conservation; iii) enlargement of the use of local runoff; v) improve strategic planning of production structure in water sector; vi) development strategies for the main water-consuming sectors of the economy.

In the practical aspect, measures to improve the organizational structure of water resources management and water-related production relations should provide for complete departmental and financial separation of function such as the construction customer, operation of main water bodies, quality control of construction and control of execution of plans distribution of irrigation water.

To increase the volume of use of local runoff, it is necessary to implement targeted projects. The construction of small reservoirs in the foothills and valleys of the Syunt-Khasardag and Kopetdag mountains - along the beds of small mountain rivers and mudflow channels can contribute to water resource development. It is also important to continue work on projects increasing the capacity of existing large and medium-sized reservoirs. Considering the latest scientific and technical achievements, more expanded possibilities for the use of drainage waters, including the "Turkmen Golden Age Lake" are emerging.

Measures to improve strategic planning of production structure and development strategies for the main water-consuming sectors of the economy seem to a very complex interdepartmental process. The most realistic measures in this regard in relation are efforts to introduce crops and varieties into agriculture, and in industry products that require the least amount of water per unit of cost of the final product.

Strategies and legislation in Turkmenistan advisable to be improved for enabling the adoption of required measures that contribute to the conservation and savings of water resources - the sustainable use of water and the provision of environmental releases. Moreover, they shall adequately suited to address future water stress predicted as a result of increased industrial and domestic water withdrawals and climate change. The water use planning shall take into account long-term needs. Therefore, water security strategy should be aimed at rational water use and based on three areas:

1. Accessible and reliable information on the availability and demand of water resources for all water users at a sectoral and territorial level;
2. Creation and development of water infrastructures for the creation of water reserves, its purification and transportation without ecosystem disturbances
3. Development and implementation of proactive measures and measures to mitigate the consequences of possible low water levels and droughts.

There are various organizational, financial, institutional and technical difficulties on the way to implementing the strategic objectives of the water sector, which complicate the holistic, integrated implementation of water supply objectives, including in relation to climate threats. This situation require clear division of water resource management tasks and water use issues between all stakeholders, between water supply organizations, regions, districts, community organizations, NGOs, and population. There are nesessary to eliminate gaps and duplication in water management, interaction between state water resources management departments and other relevant organizations. Mechanisms for interaction between ministries and departments on water resources management need to be improved for sustainable water resources management. On the way to implementing strengthened coordination, there are various organizational and technical difficulties that complicate the holistic, integrated implementation of water supply tasks in relation to risks. The priorities and tasks for their implementation often differ among the sectors of the economy of Turkmenistan and are of a distinct departmental nature, which complicates interaction on specific issues.

Strengthening institutions for water resource management and water allocation in the arid conditions of Turkmenistan is important for effectively overcoming current and future challenges. To improve the situation it is necessary to eliminate existing institutional gaps and introduce IWRM, which emphasizes the basin approach, the need to ensure effective governance institutions, and the interests of all parties involved. It is necessary to develop and adopt a set of measures for the transition to the basin principle of management, the promotion of water user associations, and changes in the legal framework for the functioning of water management relations. This should include increasing the autonomy of local water organizations and reducing the practical interference of local administrations. It follows from the articles of the Water Code that significant powers have been delegated to local authorities, and this is not entirely consistent with the concepts of IWRM and the basin approach. It is necessary to intensify actions on regulatory documents for the practical implementation of the articles of the Water Code. It will be effective if relevant organizations envisage joint measures to improve compliance with irrigation norms and minimum environmental flows. There is a need to conduct research and invest in improving the productivity of water resources and water infrastructure to gain a better understanding of the challenges involved and how best to address them. Today, the country's investment policy in water sector provides mostly O&M measures for maintaining them at a relatively stable working level. Multilateral financing mechanisms established under the UN Framework Convention on Climate Change, the Global Environment Facility, the Adaptation Fund and other funds, organizations and agencies are important in project realization and therefore cooperation with these organizations are important for the successful implementation of the state climate change adaptation program.

Government policies and programs should include environmental protection of water bodies, as well as educational campaigns and economic incentives for water users. Strengthening the technical, physical, scientific, institutional and legal potential will minimize vulnerability to various types of impacts. Also, programs for modernizing water resources management will be successful if reliable water measurement system, flexible accounting and control of water supply are established.

6.2. International cooperation for better transboundary water management

To strengthen regional and international cooperation in the field of water resources, conservation and use of transboundary water bodies is essential for the Central Asia countries, including for Turkmenistan, which share in the water allocation of the Amu Darya is 35%.

After 1994, as a result of a coordinated water conservation policy adopted by the Central Asian states at the Interstate Commission for Water Coordination (ICWC), a decrease in the total water intake became a target trend. By 2000, total water withdrawals were significantly less than in 1990. The level of use of water resources in comparison with the most advanced countries of the world, which are in similar conditions, should be considered insufficient. Recently, in this transboundary basin, cases of water use being contested across sectors and countries have become increasingly common. The issue of distribution of water resources has always been very delicate in agrarian Central Asia. In Turkmenistan in the center of attention has always been carrying out effective, well-thought-out reforms in the water and agricultural sectors. There are also difficulties in managing the water management complex on the Amu Darya, since the water bodies of Uzbekistan and Turkmenistan are located in large contiguous territories within the 5 border regional administrative bodies of the two countries. This is largely due to the legacy of the Soviet period, when there was a unified irrigation system.

Under the Nukus Declaration and other signed interstate documents obligations were accepted for their strict implementation. But there is still concerns for the discharge of water from drainage canals of Uzbekistan and Turkmenistan into the Amu Darya. Issues of water quality management should be considered together with issues of managing their quantity and distribution of water resources between water users. Such an integrated approach requires appropriate adjustments to the current legislation and norms for the interaction of the main departments of state water resources management both within the country and at the transboundary level. Since current cooperation on environmental releases and transboundary water quality monitoring is very weak, the introduction of modern approaches, the development and implementation of new observation systems will require significant financial and methodological support, including from the international community and investors. It is important to have more intensive cross-border cooperation on these issues. Moreover, it is covered in several international agreements and conventions on joint water resources management, in which the country has joined. The intention should be to develop local capacity and the readiness of key services and individuals in the country for an increasingly integrated approach to water resource management. This can be achieved by working on issues and challenges to simultaneously develop capacity and willingness to resolve cross-border and divisive issues with Central Asian governments. There is a lack of experience and knowledge related to adaptation in the transboundary aspect, so here international expertise could help fill this gap.

Taking into account the current conditions, special attention needs to be paid to regional and basin problems, including the increase in water scarcity and its uneven distribution over the territory and time.

The long-term goal of regional cooperation in the Amu Darya River basin shall serve to ensure environmental, food and energy security through the balanced development of the water and energy sectors. With the orientation of each state of the Amu Darya Basin towards the sustainable development of the entire Central Asian Region, together with integration and methods of integrated management, it is possible to outline in time a number of goals and restrictions that must be aligned and strictly implemented. Then the task of basin development comes down to harmonizing national approaches and methods, benefits and risks of water and energy resource management for the short and long term. The process must take place in connection with the priorities of the socio-economic development of countries.

As demand for water increases and water supply decreases, competition for water at the state level between downstream countries will increase. On the Central Asian regional scale, this concerns Turkmenistan too, the water resources of which have a strongly transboundary nature. The impact of climate change in this region and the expected increase in water consumption in Afghanistan create a complex context when working on long-term solutions to transboundary water sharing cooperation. This includes the ongoing work in Afghanistan, on construction of the main Irrigation Canal “Qosh-Tepa” in an earth bed, the construction of the first stage of which is considered completed. Scenarios should also consider other regional risks and challenges, for example alternative modes of the Rogun hydroelectric station in Tajikistan. Therefore, it is important to discuss and agree on how and where various measures need to be taken in order to maximize the effectiveness and efficiency in low-water conditions for all states involved in the process. The task ahead is to speed up the conclusion of relevant treaties and agreements with neighboring countries. Regarding the recent direction, the priority is the conclusion of an agreement on water issues with Afghanistan. The basic principles of water sharing with the rest of the countries of the Central Asian region are enshrined in a number of interstate agreements, but the addition of new ones and further improvement of existing ones are required to be made them more precise. The transboundary water agreements could include special provisions regarding the relative time and spatial distribution of water resources in dry years. It is also important to include approval of a mechanism for ranking water uses in the event of droughts. The Central Asian countries, through joint efforts, will have to solve a very difficult task - the development of mechanisms for the integrated management of water and energy resources of the Amu Darya and Syr Darya.

In sustainable water use, legal regulation of the use of transboundary rivers and subsequent successful practical implementation are important for Turkmenistan. Therefore, any actions taken in the country aimed at strengthening cooperation in the field of water resource distribution in a transboundary context are important. Targeted policy measures can help Turkmenistan and neighboring

Significant intensification of interstate cooperation on water data and hydrometeorological issues is necessary. Since river formation zones are mainly located in nearby countries, in relation to low water periods, achieving effective results is only possible based on close coordination with the relevant services of neighboring countries, primarily with their hydrometeorological and water management services. In terms of adaptation, Turkmenistan clearly will benefit from cooperation on measures to reduce uncertainty through information exchange, expanding the knowledge base and prevent difficulty in water supply, preparedness for extreme events and restoration of water delivery.

Thus, transboundary cooperation is vital for the Central Asia countries, including for Turkmenistan. Elaboration of common unified methodical approaches for the countries in water sharing, protection, use and conservation will support easy interactions and agreements for better transboundary water management under climate change.

6.3. Enhancing water resource management in a changing climate

Specialists and sector experts involved in the development of adaptation documents need relevant knowledge on adaptation and mitigation actions and methodologies. This is necessary for the effective integration of climate change into sector planning, including budget formation. And for this aim this is necessary to ensure access to information and accumulated experience in respective branch ministries. Based on this, the water sector should also receive support through access to the necessary climate information, technical working groups, while sharing the necessary information itself.

In the current context of water scarcity, increasing social and production needs and the increasing impact of climate change, it is necessary to find and more widely apply methods and technologies that contribute to the effective and sustainable management of irrigated lands and pastures, including remote sensing technologies and digital solution. It is possible to carry out services in with high quality if there is a specialized automated system, which includes a subsystem for receiving and automated processing of operational hydrological and agrometeorological information, data banks, and a set of programs to support the sector. To meet modern requirements, it is necessary to develop smart information systems for irrigation planning.

There is a need to replace old industry sector-based decision-making methods with a broader approach that considers the many aspects of the development chain, the multiple risks and uncertainties, the costs and benefits of each decision made. In this regard, government agencies have to put a significant contribution for more resilient, collaborative, flexible institutions; putting in place appropriate financing mechanisms for the long-term viability of water services and infrastructure and ensuring that water issues are included in day-to-day policy making.

In order to better manage water resources in irrigation systems of a higher engineering level, build them, and maintain the machinery and equipment installed as a result of modernization, current and future water specialists need new knowledge and skills. It is necessary to strengthen the potential of key persons in the relevant ministries and departments, as well as all involved persons from top to the lower in rank - in the regional and district divisions and improve them degree of awareness. The above can fully apply to the level of local authorities and resource users too. In the current conditions, in timely awareness of an integrated approach and updated knowledge about the relationship between land, water and natural ecosystems among staff will serve to ease the situation.

Mechanisms for public participation in decision-making on water supply issues shall be developed. Water for irrigation of agricultural crops shall be delivered on the cost recovery basis. The financing of water management bodies not only from the state budget, but also from different sources, including private sector, international donors is advisable to be provided to contribute implementation of the government goals and plans for the water sector development.

To achieve success, it is necessary to rely on the participation of the public and stakeholders, and on ensuring the interaction of management structures at various levels with them. It is necessary to establish constructive dialogue with relevant specialists and politicians in the Central Asian Region and at the national level. Involving the public, including non-governmental organizations, shall be fully realized for better understanding of the state water policy and requests from water users.

6.4. Strategies and future actions outline for Turkmenistan water security

Turkmenistan faces significant challenges due to limited water resources, arisen by climate change and increasing demand from agriculture. To adapt to these challenges and work towards sustainable development goals (SDGs), particularly regarding everybody's equal access to water resources, the following comprehensive recommendations are advisable to be implemented.

Water Management and Conservation, which includes implementation of modern irrigation techniques, water recycling and reuse;

Sustainable Agricultural Practices, which imply promotion of drought-tolerance crop varieties and the diversification of crops that require less water, improved soil management and wide reclamation works, as well as development of educational programs for farmers on sustainable agricultural practices and water conservation.

Climate Change Adaptation Strategies. This strategy includes creation of climate resilient infrastructure, upgrading of meteorological systems to provide timely weather information to farmers and rural communities, support research to promote innovation in agriculture and water management.

Strengthening Governance and Policy Frameworks, which include application of the integrated water resource management, focusing on equitable water distribution and sustainable use; implementation of the water pricing policies that encourage conservation and reflect the true cost of water, as well as community participation to ensure their needs are met.

Regional Cooperation, through enlargement regional dialogues with neighboring countries to ensure fair distribution of shared transboundary water resources; collaboration within the joint projects aimed at improving water efficiency and reducing pollution in shared water bodies.

Access to Clean Water and Sanitation, which imply with infrastructure development by investment in water supply and sanitation systems both in urban and also rural areas to ensure equitable access to clean water; implementation of community-managed water supply systems to enhance local ownership and maintenance of water resources; raising awareness about the importance of water conservation and hygiene practices among communities.

Monitoring and Evaluation, which require establish modern systems for monitoring water usage, quality, and availability to inform policy and management decisions; regularly assess progress towards SDGs related to clean water and sanitation, ensuring that all regions and populations benefit.

Thus, for future sustainable water use and protection Turkmenistan will depend on the country efforts to implement policies for sustainable water resource management, measures towards equitable access to water for everybody, collaborative efforts, both domestically and regionally, which are crucial in addressing the water shortage challenges arisen from the climate change effectively.

References

Aganov S., & Ovezmuradov K. (2018). Protection of water resources. Scientific collection "Nature conservation of Turkmenistan". Issue 10. Ashgabat, (Аганов С. и Овезмурадов К. Охрана водных ресурсов. Научный сборник «Охрана природы Туркменистана». Вып.10. Ашхабад, 2018).

Aganov S., Kepbanov Y., Ovezmuradov G. (2016). "Experience of agricultural restructuring in Turkmenistan". Discussion Paper No.158 Leibniz Institute of Agricultural Development in Transition Economies (IAMO). https://www.iamo.de/en/publications/iamo-discussion-papers/

Aganov, S., Kepbanov, Y., Ovezmuradov, G. (2019). Restructuring of livestock sector in Turkmenistan. Discussion Paper №189 Leibniz Institute of Agricultural Development in Transition Economies (IAMO), Halle, https://www.iamo.de/fileadmin/documents/dp189.pdf

Allaberdyev, G. (2014). "National Strategy of Turkmenistan on Climate Change". Presentation at the Seminar within the framework of the Project "Reducing risks associated with climate change in Turkmenistan" on January 28-29, 2014 in Ashgabat. (Аллабердыев. «Национальная стратегия Туркменистана по изменению климата». Презентация на Семинаре в рамках Проекта «Сокращение рисков, связанных с изменением климата в Туркменистане» 28-29.01.2014г. в г. Ашхабаде).

Annamukhammedov, O., Khanchaev Kh., Kepbanov Y., Vysov S., Shadurduev A. (2014). Natural pastures and the development of transhumance livestock farming in Turkmenistan. (Аннамухаммедов О. и др. Природные пастбища и развитие отгонного животноводства Туркменистана). https://tehranconvention.org/system/files/web/natural_pasture_compressed.pdf

Ashirbekov, U. & Zonn, I. (2003). Aral: the history of a disappearing sea. IFAS publication. Dushanbe. (Аширбеков У., Зонн И. Арал: история исчезающего моря. Публикация МФСА. Душанбе, 2003)

Balakaev, B.K., Gulmanov, G., Owemuradov, G, Tayliyev, N. (2009). Development of a set of measures for the rational use of water resources in the zone of influence of the Main Collectors of the Turkmen Lake "Altyn Asyr". Interim scientific-technical report. Institute of Turkmensuvylymtaslama". (Балакаев Б.К., Гулманов Г., Овезмурадов Г., Тайлиев Н. Разработка комплекса мероприятий по рациональному использованию водных ресурсов в зоне влияния Магистральных коллекторов Туркменского озера «Алтын асыр». Промежуточный научно-технический отчет, 2009).

Balakaev, B.K., Gulmanov, G., Owemuradov, G, Tayliyev, N. (2013) Development of a set of measures for the rational use of water resources in the zone of influence of the Main Collectors of the Turkmen Lake "Altyn Asyr". Final scientific-technical report. Institute of Turkmensuvylymtaslama". (Балакаев Б.К., Гулманов Г., Овезмурадов Г., Тайлиев Н. Разработка комплекса мероприятий по рациональному использованию водных ресурсов в зоне влияния Магистральных коллекторов Туркменского озера «Алтын асыр». Заключительный научно-технический отчет, 2013).

Bayramova, I.A. (2012). Underground waters of Turkmenistan. "Turkmengaz" State Concern. Scientific works of the Oil and Gas Institute of Turkmenistan. Ashgabat. (I.A. Baýramowa. Türkmenistanyň ýerasty suwlary. "Türkmengaz" Döwlet Konserni. Türkmenistanyň Nebit we gaz institutyniň işleri. Aşgabat. 2012)

Behnke, R., Robinson, S., Milner-Gulland, E.J. (2016) Governing open access: livestock distributions and institutional control in the Karakum Desert of Turkmenistan. Land Use Policy 52.

Bekniyaz, B.K., Budnikova, T.I., Alimbetova, Z.Zh (2018). Environmental problems in the Aral Sea basin. J. "Problems of desert development" 2018, No. 1-2.

Bogaturov, L.(2011) International relations in Central Asia: Events and documents – M.: Aspect Press (Международные отношения в Центральной Азии: События и документы. Под ред. А.Д. Богатурова. – М.: Аспект Пресс, 2011).

Chakir, R. (2005). Water resources development and effective water use in Turkmenistan. An Expert Report for Islamic Development Bank by Rural Services Research Institute, Kirklareli /Türkiye.

Chembarisov, Y. (1989). Runoff and mineralization of large reservoirs in Central Asia. J. "Water Resources". 1989. (Чембарисов Э. Сток и минерализация крупных коллекторов Средней Азии. Ж. "Водные ресурсы", 1989).

Dukhovny, V. (ed). 2002. Dialogue on water and climate: Aral Sea Basin case study. Final report. Tashkent: SIC under the Interstate Commission on Water Coordination.

Dukhovny, V. (2003). Ecological sustainability and advanced approaches to water resource management in the Aral Sea basin. Materials of Central Asian International Scientific-practical conference "Water and ECO", Almaty, May 2003 (Духовный В. Экологическая устойчивость и передовые подходы к управлению водными ресурсами в бассейне Аральского моря. Материалы Центральноазиатской международной научно-практической конференции "Water and ECO", - Алматы, Май 2003).

Dukovny, V. (2006). Water and globalization: an example of Central Asia. Tashkent (Духовный В. Вода и глобализация: пример Центральной Азии. Ташкент, 2006).

Dukovny, V., Ziganshina D., & Sokolov V. (2020). Overview of the use and management of water resources in Central Asia. A discussion document. http://cawater-info.net/library/eng/overview-wm-ca-en.pdf

FOEN (2009). Climate change in Central Asia. In maps and diagrams based on official information of countries presented in the National Communications of the UN Framework Convention on Climate Change, materials from scientific publications and information messages The project was supported by the Swiss Federal Environment Agency. Belley, France. Zoï Environment (Изменение климата в Центральной Азии. В картах и диаграммах по официальной информации стран, представленной в Национальных сообщениях Рамочной Конвенции ООН об изменении климата, материалов научных публикаций и информационн ых сообщений Проект выполнен при поддержке Швейцарского федерального агентства по окружающей среде. Belley, France. Zoï Environment Network. 2009)

Gapparov, B., Beglov, I, Nazariy, A. (2011). Water quality in the basins of the Amudarya and Syrdarya rivers. Analytical report. SIC ICWC, UNECE, CAREC. Tashkent (Б.Гаппаров, И.Беглов, А.Назарий Качество воды в бассейнах рек Амударья и Сырдарья. Аналитический отчет. НИЦ МКВК, ЕЭК ООН, РЭЦЦА. Ташкент. 2011 г.).

GoT (1996). Agreement between Turkmenistan and the Republic of Uzbekistan on cooperation on water management issues of 1996, Turkmenabat, Collection of acts of the President of Turkmenistan and decisions of the Government of Turkmenistan). (Соглашению между Туркменистаном и Республикой Узбекистан о сотрудничестве по водохозяйственным вопросам от 1996 г., Туркменабат. Сборник актов Президента Туркменистана и постановлений Правительства Туркменистана). https://faolex.fao.org/docs/pdf/bi-67058.pdf

GoT (2006) First national communication under the UN Framework Convention on Climate Change. Phase 2. Capacity building in priority areas of the economy of Turkmenistan in connection with climate change (2006). (Первое национальное сообщение по Рамочной конвенции ООН об изменении климата. Фаза 2. Наращивание потенциала в приоритетных областях экономики Туркменистана в связи с изменением климата. Ашгабат, 2006).

GoT (2009). Sanitary Code of Turkmenistan. (Санитарный Кодекс Туркменистана) https://www.fao.org/faolex/results/details/en/c/LEX-FAOC145496/

GoT (2010). Drinking Water Law. (Закон ''О питьевой воде''. Утвержден 25 сентября 2010 года, №136-IV. https://faolex.fao.org/docs/pdf/tuk105947.pdf

GoT (2011,1). National program of socio-economic development of Turkmenistan for 2011-2030 (Национальная программа социально-экономического развития Туркменистана на 2011-2030 г.г. САПТРПТ, 2011).

GoT (2011,2). General Program for providing clean drinking water to populated areas of Turkmenistan." (Генеральная программа обеспечения чистой питьевой водой населенных пунктов Туркменистана. Ашгабат, 2011).

GoT (2014). Resolution of the President of Turkmenistan “On the transfer to private ownership of livestock leased” (Постановление Президента Туркменистана “О передаче в частную собственность скота, переданную в аренду” . САПТРПТ. 2014).

GoT(2015). Program of activities for 2015-2020 on efficient use of water resources in Turkmenistan and improvement of water permeability of the Garakum River. (Türkmenistanda suw serişdelerini tygşytly peýdalanmak we Garagum derýasynyň suw geçirijiligini ýokarlandyrmak boýunça geçirilmeli işleriň 2015-2020-nji ýyllar üçin Maksatnamasy. 2015).

GoT (2019). Program of the President of Turkmenistan on Socio-economic Development of the Country for 2019-2025 (Türkmenistanyň Prezidentiniň ýurdumyzy 2019 — 2025-nji ýyllarda durmuş-ykdysady taýdan ösdürmek boýunça maksatnamasy).

GoT (2020). Decree of the President of Turkmenistan No. 1970 dated 23.11.2020 on creation of Intersectoral Commission on environmental issues (Постановление Президента Туркменистана № 1970 от 23.11.2020 г. о создании Межотраслевой комиссии по вопросам охраны окружающей среды). https://turkmenportal.com/en/blog/31508/the-president-of-turkmenistan-has-created-an-intersectoral-commission-on-environmental-protection

GWP (2009). Water supply and sanitation in the countries of Central Asia and the South Caucasus, Regional overview. (Глобальное водное партнерство, Центральная Азия и Кавказ, Водоснабжение и санитария в странах Центральной Азии и Южного Кавказа, Региональный обзор. 2009).

GWP (2006). Issues of implementation of Integrated Water Resources Management in achieving the UN Millennium Goals. Materials of the seminar of GWP and Ministry of Foreign Affairs of Turkmenistan. Collection of articles. Ashgabat (Вопросы реализации Интегрированного управления водными ресурсами в достижении целей Тысячелетия ООН. Материалы семинара ГВП и МВХ Туркменистана. Сборник статей. Ашгабат, 2006).

Hallyklychev, B. & Atayev, D. Information on drainage systems and water taken from sources in Turkmenistan. Annual reports of the IC “Turkmen Lake of the Golden Age” of Institute of Turkmensuvylymtaslama”. Ashgabat, 2014 (Türkmenistandaky zeýkeş ulgamlary boýunça we çeşmelerden alnan suwlar barada maglumatlar. “Türkmensuwilimtaslama” institutynyň “Altyn Asyryň Türkmen köli” MM-iň ýyllyk hasabaty Aşgabat, 2014).

Ilamanov, A., Babayev, A., Batyrov A. (1996). A drop of water is a grain of gold (in Turkmen language) Ashgabat. (Ilamanow A., Babaýew A., Batyrow A. Suw damjasy - altyn dänesi. Aşgabat, 1996).

Turkmensuvilymtaslama (2007). Program of development of agriculture of Turkmenistan for the period until 2030. Water management system. (Программа развития сельского хозяйства Туркменистана на период до 2030 г. Система водного хозяйства. Разработана Институтом «Туркменсувылымтаслама» 2007).

Irrigation regimes for agricultural crops in the Turkmen SSR. Ashgabat. 1990 (Поливные режимы сельскохозяйственных культур в Туркменской ССР. Ашхабад. 1990).

Khosrt, M. (2002). Possible ways to increase the level of rational water use in irrigated agriculture in the Aral Sea basin in connection with climate change. Report on the Project “Dialogue on Water and Climate: Aral Sea Basin Case Study”. Publication SIC ICWC, Tashkent. (Хосрт М. Возможные пути повышения уровня рационального водопользования в орошаемом земледелии бассейна Аральского моря в связи с изменением климата. Отчет по Проекту «Dialogue on Water and Climate: Aral Sea Basin Case Study». Публикация НИЦ МКВК, Ташкент, 2002).

Kurtovezov, G. (2008). Integrated use of water resources. (Куртовезов Г. Комплексное использование водных ресурсов. Ашхабад, 2008).

GoT (1998). Land use and tenure in Turkmenistan. Ashgabat-Almaty, (Постановление Президента Туркменистана от 15 ноября 1991 г. “Об утверждении государственного акта на право владения и пользования землей на территории Туркменской ССР”. В кн.: Землевладение и землепользование в Туркменистане. Сборник нормативных актов. Ашхабад – Алматы, Экологический клуб CATENA, 1998, с. 98-99.).

GoT (1999). First national communication (1999) under the UN Framework Convention on Climate Change. (Туркменистан. Первое национальное сообщение по Рамочной конвенции ООН об изменении климата. Ашгабат, 1999).

GoT (2009). Second national communication under the UN Framework Convention on Climate Change (Второе национальные сообщение Туркменистана по Рамочной конвенции ООН об изменении климата, 2009)

GoT (2012). Low "About especially protected natural territories".

GoT (2014). Law "On environmental protection". Adopted in March 2014 with amendments and additions dated August 18, 2015 and March 20, 2017. (Закон ''Об охране природы Туркменистана'', принятый в марте 2014 г. с изменениями и дополнениями от 18 августа 2015 г. и от 20 марта 2017 г.). https://www.fao.org/faolex/results/details/en/c/LEX-FAOC132755/

GoT (2015) Third national communication under the UN Framework Convention on Climate Change (Третье национальные сообщение Туркменистана по Рамочной конвенции ООН об изменении климата, 2015).

GoT (2016). Water Code of Turkmenistan (Водный кодекс Туркменистана от 2016г.) http://www.cawater-info.net/library/rus/legal_41.pdf

GoT (2018). The Law "On Land Reclamation". (Закон Туркменистана «О мелиорации земель). https://www.fao.org/faolex/results/details/fr/c/LEX-FAOC184358/

GoT (2019). Voluntary National Review of Turkmenistan. Empowering people and achieving inclusiveness and equality. (Добровольный национальный обзор Туркменистана. Расширение прав и возможностей людей и обеспечение всеобщего охвата и равенства. 2019)

GoT (2023). Voluntary National Review. Turkmenistan. On the progress of implementation of the global Agenda for Sustainable Development." (Добровольный национальный обзор. Туркменистан. О ходе реализации глобальной Повестки дня в области устойчивого развития». 2023) http://www.fine-economic.gov.tm/sdg/6-njy-macsat

GWP CAC, 2006. Implementing the UN Millenium Development Goals in Central Asia and the South Caucasus: Goal 7: Ensure Environmental Sustainability.Conserving Ecosystems of Inland Water Bodies in Central Asia and the South Caucasus. Almaty-Tashkent, 2006. https://www.gwp.org/globalassets/global/gwp-cacena_files/en/pdf/ecosystem_e.pdf

Lerman, C., Punda, I., Sedik, D. et al. (2014). Turkmenistan. Review of the Agri-Food Sector. EBRD/FAO.

Lerman, Z. Prikhodko, D., Punda, I., Sedik, D. Serova, E., Swinnen, J. (2012) Turkmenistan Agricultural sector review. FAO Investment Centre Division.

Meleshko, L. et al. (2005). Anthropogenic climate changes in the 21st century in Northern Eurasia. Sat. stat. "Climate Change: What the Science Says." Publication of the ICWC Training Center, vol. 12. Tashkent. (Мелешко Л. и др. Антропогенные изменения климата в XXI веке в Северной Евразии. Сб. стат. «Изменение климата: что говорит наука». Публикация Тренингового центра МКВК, вып. 12. Ташкент, 2005).

MMWM USSR, 1987. Schemes of complex use and protection of water resources for the Amu Darya (1987) river basin. Approved by the Ministry of Melioration and Water Management of the USSR. (Схемы комплексного использования и охраны водных ресурсов по бассейну рек Амударья, 1987 г.Утверждено Министерством мелиорации и водного хозяйства СССР).

Mejlis of Turkmenistan(1992). Constitution of Turkmenistan (new version) (with amendments and additions as of 21.01.2023. Bulletin of the Mejlis of Turkmenistan», 1992, No. 5, Art. 30. (Конституция Туркменистана (новая редакция) (с изменениями и дополнениями по состоянию на 21.01.2023 г. Ведомость Меджлиса Туркменистана, 1992 год, № 5, ст.30.). https://online.zakon.kz/Document/?doc_id=31337929&pos=6;-109#pos=6;-109&sel_link=10065 15282

Mislimshoeva B., Abdurasulova G., Walsh J. & Statz J. Institutional Analysis of the Current National System and Processes Related to Climate Change in Turkmenistan. An analysis to inform the development of the NAP processes and sectoral integration of climate change adaptation. https://napglobalnetwork.org//wp-content/uploads/2021/06/napgn_ru_2021_institutional-analysis-of-the-current-national-system-and-processes-related-to-climate-change-in-turkmenistan.pdf

MWET (2000). Reclamation state of irrigated lands of Turkmenistan for 1999. Annual Bulletin of the Hydrogeological and Reclamation Expedition of the MWET - Ashgabat, 2000 (Мелиоративное состояние орошаемых земель Туркменистана за 1999 г. Ежегодный бюллетень Гидрогеолого-мелиоративной экспедиции МВХ Туркменистана. Ащхабад, 2000).

Nazarmamedov O, Gulmanov G., Ovezmuradov G. (2013). Monitoring of drainage channels in Turkmenistan and development of recommendations for increasing their efficiency. Final report of NIR for 2009-2013. Institute “Turkmensuvilymtaslama” MWET. (Nazarmamedow O, Gulmanow G., Öwezmyradow G. Türkmenistanyň zeýkeşakabalaryna gözegçilik we netijeliligini ýokarlandyrmak üçin teklipleri işläp düzmek. 2009-2013-nji ýyllar üçin Jemleýji ylmy-gözleg hasabaty. “Turkmensuvylymtaslama” instituty. Aşgabat, 2013).

NEAP (2002). Ashgabat (Национальный План Действий по Охране Окружающей Среды (НПДООС). Ашгабат, 2002).

NEAP, 2002. (План Действий по Охране Окружающей Среды. Ашгабат, 2002).

NISSI (2012). Modern problems of transitioning the agro-industrial sector of Turkmenistan to market-innovative development. Institute of Strategic Planning and Economic Development of Turkmenistan). (Türkmenistanyň agrosenagat toplumyny bazar-innowasion häsiýetli ösüşe geçirmekligiň häzirkizaman meseleleleri. Türkmenistanyň Strategik meýilnamalaşdyryş we ykdysady ösüş instituty. Aşgabat, 2012).

NISSI (2017). Agriculture in Turkmenistan in 2015-2016. (Turkmenistanyn oba hojalygy 2015-2016-nji ý.ý. Türkmenistanyň Milli statistika we maglumat instituty. 2017 ý.).

NISSI (2019). Agriculture in Turkmenistan in 2017-2018. (Turkmenistanyn oba hojalygy 2017-2018-nji ý.ý. Türkmenistanyň Milli statistika we maglumat instituty. 2019 ý.).

OECD (2010). Ten years of reform of the water supply and sanitation sector in the countries of Eastern Europe, the Caucasus and Central Asia.

OECD (2016), Financing Climate Action in Turkmenistan. Paris. https://www.oecd.org/ environment/outreach/Turkmenistan_Financing_Climate_Action.Nov2016.pdf/

Orlovsky, N., & Orlovsky, L. (2002). Water resources of Turkmenistan: use and conservation. In workshop on water, climate, and development issues in the Amu Darya basin, Philadelphia, USA.

Pohl B., Kramer A., Hull W., Blumstein S., Abdullaev I., Görlitz S. (2017). Rethinking Water in Central Asia: the costs of inaction and benefits of water cooperation. https://carececo.org/ Rethinking%20Water%20in%20Central%20Asia.pdf

Saparov O. (2007). Water blessing source. New Village Journal, No. 3, 2007. (Saparow O. Suw bereket çeşmesi. Täze oba zurnaly, № 3, 2007).

Saparov, O., Hallyklychew, B., Nurmuhamedowa, G. (2004). Assessing the impact of the crisis in Afghanistan on the water quality of the Amu Darya River in Turkmenistan. Report for UNDP and the Government of Turkmenistan (Оценка влияния кризиса в Афганистане на качество воды реки Амударья в Туркменистане. Отчет для ПРООН и Правительства Туркменистана. 2004).

Shpakov A. (2010). Abnormal heat awaits Central Asia. Forecasters predict the hottest summer in the history of meteorological observations. (Шпаков А. Центральную Азию ждет аномальная жара. Синоптики предрекают самое жаркое лето за всю историю метеонаблюдений.

SIC ICSD (2005,1). Climate change: affects everyone. Publications, issue 11. Tashkent. (Изменение климата: касается каждого. Публикации НИЦ МКУР (выпуск 11). Ташкент, 2005).

SIC ICSD (2005,2). Climate change: What science says. Publications, issue 12. Tashkent. (Изменение климата: что говорит наука. Публикации НИЦ МКУР (выпуск 12). Ташкент, 2005).

Sokolov V. (2023). The impact of climate change on water resources and the task of adaptation. Presentation; UNDP/ZKF project “Development of national adaptation planning process in Turkmenistan”. 13-15.11.2023, Dashoguz city. (Соколов В. Влияние изменения климата на водные ресурсы и задачи по адаптации. Презентация; Проект ПРООН/ЗКФ «Развитие национального процесса планирования адаптации в Туркменистане». 13-15.11.2023 г., г.Дашогуз).

SSC of Turkmenistan (2002). Environmental protection and use of natural resources in Turkmenistan (Государственный комитет по статистике Туркменистана. Охрана окружающей среды и использование природных ресурсов в Туркменистане).

SSC of Turkmenistan (2009). Environmental protection and use of natural resources in Turkmenistan. (Государственный комитет по статистике Туркменистана. Охрана окружающей среды и использование природных ресурсов в Туркменистане, 2009).

SSC of Turkmenistan (2012). Environmental protection and use of natural resources in Turkmenistan (2012). (Государственный комитет по статистике Туркменистана. Охрана окружающей среды и использование природных ресурсов в Туркменистане).

SSC of Turkmenistan (2015). Environmental protection and use of natural resources in Turkmenistan (2015). (Государственный комитет по статистике Туркменистана. Охрана окружающей среды и использование природных ресурсов в Туркменистане).

SSC of Turkmenistan (2020). Environmental protection and use of natural resources in Turkmenistan (2020). (Государственный комитет по статистике Туркменистана. Охрана окружающей среды и использование природных ресурсов в Туркменистане.

SSC of Turkmenistan (2022). Environmental protection and use of natural resources in Turkmenistan. (Государственный комитет по статистике Туркменистана. Охрана окружающей среды и использование природных ресурсов в Туркменистане, 2022).

SSC of Turkmenistan (2023). Environmental protection and use of natural resources in Turkmenistan (Государственный комитет по статистике Туркменистана. Охрана окружающей среды и использование природных ресурсов в Туркменистане, 2023).

Stanchin, I. & Lerman C., (2003). Agrarian reform in Turkmenistan. Israel, Rehovot: Jerusalem University. http://departments.agri.huji.ac.il/economics/lerman-turk-water.pdf

Stanchin, I., Lerman, C., Sedik, D. (2011) Potential for Income Growth of Rural Population in Turkmenistan Based on Alternative Agricultural Crops. Published by FAO UN – Regional Office for Europe and Central Asia. (И. Станчин, Ц. Лерман, Д. Седик. Потенциал роста доходов сельского населения Туркменистана на основе альтернативных сельскохозяйственных культур. Издание ФАО ООН – Региональное бюро по Европе и ЦА).

Satymov R. (2022). Water shortage: can desalination help Turkmenistan? Article, Progres IP. https://progres.online/society/water-shortage-can-desalination-help-turkmenistan/

TYPSA (2019). Water supply from the Caspian Sea. Desalination plant, transport pipelines and power generation plants. Key facts. https://www.typsa.com/en/projects/water-supply-from-the-caspian-sea-desalination-plant-transport-pipelines-and-power-generation-plants/

UNDP, 2012,1. Investment and Financial Flows (I&FF) Assessment Report. Assessment of investment and financial flows to address climate change mitigation in the Water sector. https://climatepromise.undp.org/sites/default/files/research_report_document/undp-iff-turkmenistan -assessment-water-en.pdf

UNDP (2012,2) Sustainable Land Management Situational Analysis and Development Prospects” (group of authors). Publication SLM Capacity Building project.

UNDP (2024). Integration of adaptation to the consequences of climate change into water planning in Turkmenistan. Training manual for trainers. UNDP NAP project. Tashkent-Ashgabat. 2024 (Интеграция адаптации к последствиям изменения климата в водохозяйственное планирование в Туркменистане. Учебное пособие для тренеров. Проект НАП ПРООН. Ташкент-Ашхабад. 2024).

Volmuradov, K(2018). Water resources of Turkmenistan: potential, use, technology and environment. Report. (Водные ресурсы Туркменистана: потенциал, использование, технологии и окружающая среда). http://www.cawater-info.net/library/rus/almaty/volmuradov.pdf

MWET(2011) Water management of Turkmenistan. 2011 (. Водное хозяйство Туркменистана. Минводхоз Туркменистана. Ашгабат, 2011).

WMO and UNEP (2008). IGECC Technical Paper VI “Climate Change and Water Resources” (Технический документ VI МГЭИК «Изменение климата и водные ресурсы». Публикация ВМО и ЮНЕП, 2008).

Volovik, Y. (2014). Approaches to assessing climate risks at the national and regional levels (Presentation by. at the Seminar within the framework of the Project “Reducing risks associated with climate change in Turkmenistan” 01.28-29.2014, Ashgabat (Подходы к оценке климатических рисков на национальном и региональном уровнях. Презентация Е. Воловика на Семинаре в рамках Проекта «Сокращение рисков, связанных с изменением климата в Туркменистане» 28-29.01.2014г. Ашхабад).

Volovik, Y. (2010). Assessment of Water Sector in Turkmenistan. Report UNDP Turkmenistan. http://www.cawater-info.net/bk/water_law/pdf/tm_water_sector_assessment_en.pdf

Yablokov, A. (2006). Impact of global warming on glaciers and glacial lakes in Tajikistan. Expert assessment. Publishing house. “Glavtajikhydromet”, Dushanbe. (Яблоков А. Воздействие глобального потепления на ледники и ледниковые озера в Таджикистане. Экспертная оценка. Изд-во. «Главтаджикгидромет», Душанбе).