Climate Change Impact on Agriculture and Water Resources: Uzbekistan

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Contents

Abstract

This article gives a summary of a research in Uzbekistan that looked at the main social and technological issues surrounding the sustainable use of water and land resources in agriculture. In Uzbekistan, a concept for the implementation of national goals and objectives in the field of sustainable development for the period up to 2030 was developed in response to changing climatic conditions, increased droughts, changes in river flow, and an increase in water demand. A comparative analysis of the costs of agricultural land was carried out using the example of cotton production employing drip irrigation technology in some regions of the republic, based on the study of the experience of effective management of water and land resources in arid regions. In Kasbi district of Kashkadarya area, research is also being conducted on the effectiveness of implementing new technologies on irrigated agricultural lands. Based on the findings of the study, it can be concluded that the use of drip irrigation in agriculture, as well as the reconstruction of existing irrigation and drainage infrastructure in the context of climate change, will lead to the long-term sustainability of Uzbekistan's water and land resource use.

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Keywords

Uzbekistan · Climate change · Sustainable development of water and land resources · Drip irrigation technology

Introduction

The main challenges for the water sector in Uzbekistan today and in the future are the decrease in water resources because of climate change and an increase in water demand due to population and economic growth. In 2017–2019, the growth of the Uzbekistan economy averaged 5.3%. In 2020, despite the impact of the COVID-19 pandemic, the country's economy was one of the few in the Europe and Central Asia region where GDP decline was avoided and its growth held at 1.6%.

Uzbekistan is the largest country in Central Asia in terms of population, which demonstrates its rather rapid growth. From 2000 to 2021, it increased by 41.1%, and the average annual growth rate was 1.65%. As a result, during this period, the population of Uzbekistan increased by 10.071 million people. Moreover, there is a gradual acceleration of the average annual growth rate of the population; for the period of 2000–2010, this figure showed 1.35%, while the later period of 2010–2021 showed its growth and reached a figure of 1.93%.

Global warming is negatively affecting the water supply of the agricultural sector of the republic. In many parts of the world, the amount and regularity of precipitation have changed. Droughts and floods are increasing, and as a result, water scarcity and competition for water resources are increasing. FAO experts assess the level of pressure on water resources in Uzbekistan as being at a critical level (over 100%). The volume of water used from water reserves accounts for 169% of the total (FAO 2021). Uzbekistan ranked 25th out of 164 in the ranking of countries suffering from water stress published by the World Resources Institute (World Resource Institute 2019). For Uzbekistan, the shortage of water is considered an emergency situation, taking into account the shortage in a number of regions of Uzbekistan, particularly in the Karakalpakstan region, which can lead to a social and environmental disaster. It should be kept in mind that the climate in the entire Central Asian region is rapidly changing as well as its warming, which increases the need for water sources. Uzbekistan, like the rest of Central Asia, is threatened by climate change problems, which can lead to the melting of the mountain glaciers that feed the main rivers of the region.

Over the past 50–60 years, glacier areas in Central Asia have decreased by about 30%. According to the forecasts, with an increase in the average annual temperature of 20 °C, glaciers can lose up to 50% of their volume, and with continuous warming reaching 40 °C, the loss would reach up to 78%. By 2050, there is the possibility of a reduction of water resources in the Amu Darya basin by 10–15%. In the Syr Darya river basin, the water might be reduced by up to 2%. With a further increase in air temperatures, the river runoff decreases. Rivers of the Amu Darya basin and small streams are more sensitive to climate warming (Rashid Kulmatov 2014).

In recent decades, there has been a visible reduction in water uptake. Recently, the annual volume of water resources used by Uzbekistan is on average 51–53 km^3 per year, which is 20% less than in the 1980s of the last century (despite the fact that during this time the country's population has doubled) (World Development Indicators 2017).

Growing water scarcity is exacerbated by the highly inefficient use of water in its delivery and consumption, especially in agricultural fields. The combination of semi-desert and desert conditions, agricultural dependence on irrigation, and progressive climate change means that crop failures can affect entire regions, jeopardizing alimentary crops.

Climate change also negatively affects the availability of water for agriculture, where high input costs for primary production also put the relative stability of food production and supply at high risk.

Agricultural production success varies from region to region, and this is highly dependent on an increase in the number of extreme climate events such as prolonged periods of drought. As a result, sustainable food production and supply can no longer be sustained without proper management of all risks and the implementation of sustainable agriculture principles.

Uzbekistan: Climate Change and Agriculture

The irrigated lands of Central Asia are mostly located in Uzbekistan. The agricultural sector is the main consumer of water resources in Uzbekistan (Fig. 1).

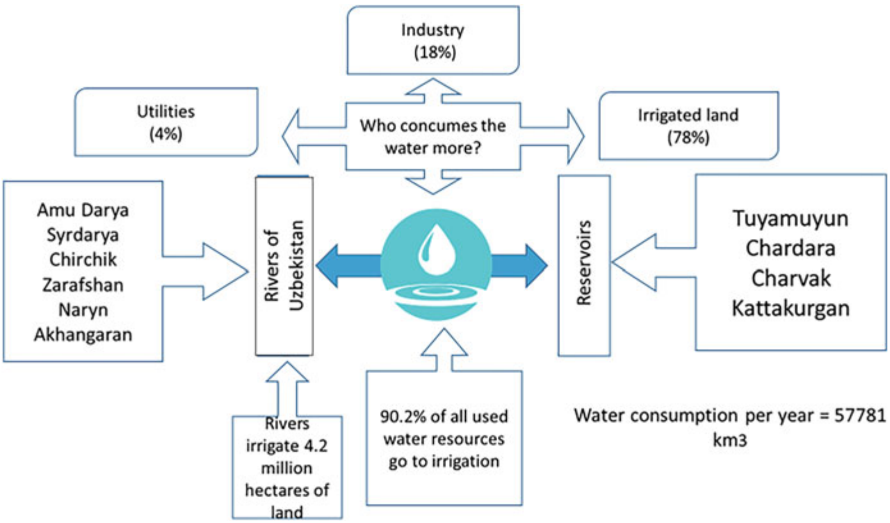

Fig. 1 The distribution of water resources in Uzbekistan. (Source: The condition of environment and use of natural resources in Uzbekistan: Statistic Committee and the State Committee on wildlife management, Tashkent, 2019, https://data.gov.uz/en/sphere/authority/28?page=5&per-page=10)

The agricultural sector is regarded as the most important economic sector in Uzbekistan, accounting for approximately 25% of the country's GDP, or $15 billion USD. According to the State Committee on Statistics of the Republic of Uzbekistan, the contribution of agriculture to GDP growth in 2020 reached 0.8%, which exceeds the contribution of other industries and services. The share of employment in this sector consists of 25.7%, or 3.4 million people (World Development Indicators 2017).

The republic is the sixth largest cotton producer in the world. Currently, the share of agriculture in the Republic of Uzbekistan exceeds the average for low-income countries (16.2%) and is close to the average for middle-income countries (25.1%). The high level of employment in agriculture indicates a low level of implementation of technological solutions in this sector and its high labor intensity. In addition, about 50% of the population of Uzbekistan lives in rural areas, which also explains the relatively high level of employment in this area.

At the end of 2020, the total volume of agricultural, forestry, and fisheries production in Uzbekistan amounted to 260.3 trillion Uzbek sum. In the total volume of agricultural, forestry, and fishery products, the share of crop production, hunting, and services provided in these areas amounted to 96.7%, the share of forestry was 2.6%, and the share of fisheries was 0.7%. The volume of agricultural production in 2020 reached 249.8 trillion Uzbek sums, including crop production of 123.6 trillion Uzbek sums and livestock products of 126.2 trillion Uzbek sums.

Because of the agrarian reforms held in agriculture and other sectors of the agro-industrial complex of Uzbekistan, there are significant socioeconomic transformations that have taken place within the country. Diverse agriculture was formed. Today, the share of farmlands within the gross agricultural output is 27.8%. This indicator reached almost 100% in cotton growing and in grain growing up to 84%. The share of dehkan farms (local farms) in the total volume of agricultural products was 68%, and the share of organizations engaged in agricultural activities reached 4.2%.

Changes are also taking place in the structure of sown areas; in particular, there is a continuous declining tendency in the cotton area and an increase in the area of grain crops (including wheat), vegetables, fodder crops, and others. This was facilitated by the abolition of state regulation of prices, as well as the production plan and mandatory sale of cotton in accordance with the Decree of the President of the Republic of Uzbekistan "On measures for the widespread introduction of market principles in the cotton sector." According to the document, starting in 2020, raw cotton producers (farms, cotton-textile clusters, and cooperatives) are given the right to freely distribute the zoned cotton.

Presidential Decree of the President of the Republic of Uzbekistan "On measures for the widespread introduction of market principles in the production, purchase and sale of grain" provides the 25% reduction in the plan for the mandatory sale of grain in 2020, and starting from the harvest of 2021, the state will completely abolish purchase prices for grain and government procurement of grain.

At present, the share of cotton in the structure of sown areas is 36.2%, cereals 45.3% (including wheat 39.5%), fodder 8.6%, and vegetables 4.7%. These facts indicate that in the development of agriculture, Uzbekistan pays attention to the cultivation of food crops. The visible tendency in the period of 2015–2017 of an increase in the areas occupied by legumes and fodder crops (including alfalfa) contributes to an increase in soil fertility, but it is still under further development. In 2015, the area occupied by leguminous plants amounted to 0.5% (17.5 thousand hectares) of the total area of sown land and fodder (8.6%) (320.4 thousand hectares), while in 1999, the total area of legumes and forage crops was 13.2% (475.2 thousand hectares).

In this way, it can be noted that a high proportion (more than 81%) of crops that deplete the soil remain in the structure of crops, which does not meet environmental requirements and can naturally contribute to the development of processes leading to land degradation (State Committee of the Republic of Uzbekistan for Nature Protection 2013).

Irrigation of new territories, including the construction of reservoirs, canals, collector and drainage networks, and other irrigation and reclamation structures, leads to changes in geotechnical, hydrogeological, and landscape conditions. As a result of underestimation of the features of loess species in Central Asia, which for a long time of their existence were in an arid climate in a state of natural equilibrium, the irrigation conducted here contributed to a sharp increase in humidity, which in turn weakened the structural bonds and strength characteristics of the rock and led to land degradation.

Over the 50-year period of modern irrigation, several changes have happened within the process itself, such as subsidence deformations, erosions, gully formations, suffusion processes, pseudokarsts, landslide processes, surface washout, recycling of the banks of reservoirs, and erosion of the banks of irrigation canals. In connection with the rise of the groundwater level and the moistening of loess rocks in the aeration zone, there are currently two urgent problems, which are salinization and waterlogging (Mavlyanova et al. 2016).

Progressive climate change exacerbates the difficulties of agricultural production in semi-desert and desert conditions, posing a threat to the population.

Of the total land area of Uzbekistan (447,400 km^2), irrigated land reaches up to 42,150 km^2 of its territory (Fig. 2). Irrigated lands in Uzbekistan are considered the most valuable agricultural lands in the world. The size of the country's irrigated fund is limited by the availability of irrigation water in irrigation sources. A complex water management system has been created for a total irrigated area of 4.3 million hectares. The total length of the inter-farm irrigation network in Uzbekistan is more than 27.7 thousand km. On-farm, 167.4 thousand km (of which, respectively, 62% and 79.5% pass through the earthen channel), 55 reservoirs have been built with a total volume of 20 km^3. On the irrigated area, which consists of more than 2.5 million hectares, there are 136.7 thousand km of drainage networks, and 3344 vertical drainage wells are in operation (Open Data Portal of the Republic of Uzbekistan/Irrigated lands of the land fund of the Republic of Uzbekistan 2015).

In previous years, especially until 1991, the increase in production was achieved due to the growth of irrigated land and chemicalization. A sharp increase in the load

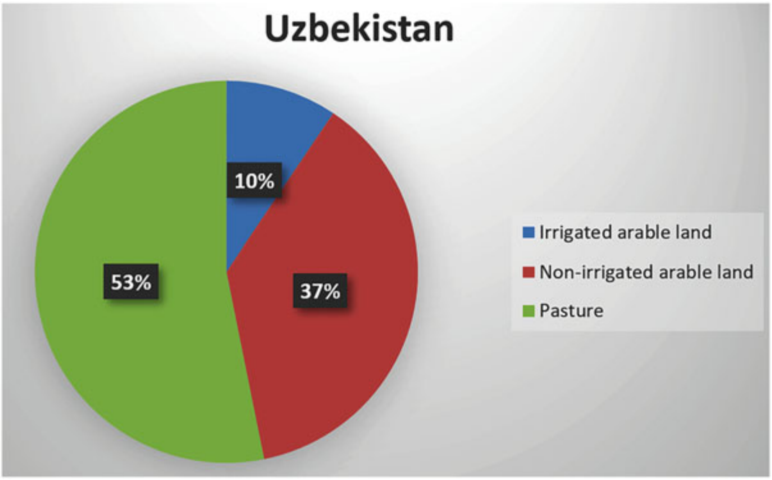

Fig. 2 The condition of the environment and the use of natural resources in Uzbekistan, https://data.egov.uz/rus/data/6116649f114fbfdc20c36827. (Source: Statistic Committee and the State Committee on wildlife management, Tashkent, 2019, Open Data Portal of the Republic of Uzbekistan/Irrigated lands of the land fund of the Republic of Uzbekistan)

on the soil caused its salinization, pollution with pesticides and heavy metals, depletion of humus, the development of erosion, and other negative phenomena.

It is also necessary to note one more feature, which is that there is a sharp fluctuation in the specific norms of water consumption for irrigation (about 80% of all used water resources) by regions. The lowest values are found in Samarkand (7.1 thousand m^3/ha), Jizzakh (7.3 thousand m^3/ha), and Syr Darya (7.5 thousand m^3/ha), while the highest are found in the Khorezm region (15.5 thousand m^3/ha), the Republic of Karakalpakstan (13.2 thousand m^3/ha), and the Bukhara region (12.1 thousand m^3/ha), which is due in part to the need for annual leaching of saline lands.

The main reason for the current situation in specific norms of water consumption is the difference in climatic and soil-reclamation conditions, water supply conditions, etc., but practice shows that there are cases of irrational use of irrigation water and land resources (Central Asia Water and Ecology Knowledge 2020).

Agriculture has an important role to play in the mitigation of greenhouse gas emissions (GHG), which is second only to the energy sector. In 2017, agriculture accounted for 17.8% of total greenhouse gas emissions in Uzbekistan. The volume of emissions is equal to 33.7 million tons of CO_2 equivalent (UNEP 2021).

This problem has both institutional and technological reasons. Insufficiently effective management of irrigation systems and water infrastructure (e.g., pumping stations) and the resulting salinization and waterlogging processes create additional risks and costs for the country. Water delivery to the destination can reach up to 37%. The consulting firm Royal Haskoning (2003) estimated that agricultural losses due to poor management in Uzbekistan amounted to about 919 million USD per year in the Syr Darya and Amu Darya basins. This problem is exacerbated by the fact that

75% of pumping stations used for irrigated agriculture have long been operating beyond their service life and need to be replaced (Ramazanov 2019).

In total, there are 1687 pumping stations in Uzbekistan. Of these, 299 became obsolete. As a result, 80 thousand hectares of land were out of use. Water supply deteriorated in an area of 607 thousand hectares. Due to the fragmentation of the locks, there is no monitoring of the water supply to the consumers.

According to analyses by national experts, annual losses due to the "withdrawal of irrigated land from agricultural use" (Supplement to the National Report) amounted to 212 million USD. Given sufficient water resources, full-scale irrigation of all land equipped for irrigation will result in higher yields and significant agricultural benefits.

A correct and well-thought-out policy for agriculture and the rational use of water resources is needed to prepare for worsening droughts, changes in river flows, and an increase in water demand due to climate warming conditions.

Poor management of water and land resources, aggravating the impact of climate change in Uzbekistan, is facilitated not only by technological but also by institutional reasons. The Ministry of Water Resources implements a unified policy for the management of the country's water resources. Currently, responsibility for the country's water resources is divided among several government ministries and departments, which leads to inefficient use of these resources.

The main costs of delivering water to farmers are covered by the state budget. Farmers' payments for water delivery services are not directly linked to the volume of water consumed. Their size is insufficient to stimulate productive and economical water use.

Administrative (non-market) methods still dominate in the management of water supply in the agricultural sector, as in all agriculture in general. The main instruments for water distribution are arbitrarily assigned quotas for water distribution and administrative control over the crop structure. The tasks of fulfilling plans for the production of cotton and wheat are not tied to the tasks of optimizing crops in terms of maximizing economic benefits, increasing farmers' incomes, increasing water supply, and reducing the cost of water delivery.

Low qualification of irrigators leads to inefficient use of water resources. The experience of advanced countries in this area is practically not used. Technological problems in the use of water resources are associated, first of all, with outdated and worn-out infrastructure.

In Uzbekistan, the volume of electricity used in the pump irrigation system is 16% of the total electricity consumed by the country. Most of the pumping stations have been in operation for more than 30–40 years and are in need of reconstruction and overhaul. The main measures for energy conservation and reduction of greenhouse gas emissions in this sector are related to the renovation and modernization of pumping units of electrical equipment on irrigation systems and vertical drainage systems. As a result of the implementation of projects for the reconstruction of existing and construction of new pumping stations, the reduction of greenhouse gas emissions amounted to 51 thousand tons of CO_2/year (Niyazmetov and Rudenko 2018).

With the continuous deterioration of irrigation systems and hydraulic structures operated for decades, the high energy intensity and low productivity of technological equipment and structures lead to significant losses of water and high costs of its delivery to consumers. Thus, 66% of main and inter-farm and 21% of local canals in the country do not have anti-seepage coatings, which means they pass through earthen channels. 44% of main and inter-farm and 42% of local canals require repair and restoration, and 16% of main and inter-farm and 10% of local canals require reconstruction. The technical condition of 70% of trough networks is assessed as unsatisfactory. As a result, water losses in irrigation networks reach up to 35–40%.

In addition, the main parts of the hydraulic structures of the water management system are assessed as physically worn out and morally obsolete. For example, the service life of more than 60% of the pumping equipment on the balance sheet of the Ministry of Water Resources has expired. The physical and moral deterioration of pumping stations and their constituent elements (pumping units, engines, and electrical parts) is the main reason for large losses of electricity.

Uzbekistan signed the Paris Agreement on April 19, 2017 and ratified No. 3RU-491 in 2018, taking on quantitative commitments to reduce greenhouse gas emissions.

Uzbekistan's key CAP commitment is to reduce greenhouse gas emissions per unit of GDP by 10% by 2030 in relation to 2010. Unconditional implementation of the Paris Agreement is a basic component of the country's climate policy.

At present, the total greenhouse gas emissions of the Republic of Uzbekistan are about 200 million tons of CO_2-eq. In terms of emissions, the country occupies 38th place in the world ranking, 4th place among the CIS countries, and 2nd place in the Central Asian region.

According to projected climate change data, irrigation rates will increase by 5–10% by 2030. If the current model of land and water management continues, food shortages will increase, land quality will deteriorate, and water supplies will decline. The management of water and land resources in Uzbekistan requires an integrated approach, taking into account the characteristics of the landscape and climatic conditions. The main measures to reduce greenhouse gas emissions in economic sectors are aimed at modernizing the water sector and agriculture.

Massive gains have been made in the management and control of irrigation systems in the last 20 years, with much success in retrofitting modern technology to existing infrastructure. The key focus of these changes has been on:

- Better understanding of when it is best to apply water to crops and how much to apply. This improved understanding has been enabled by breakthrough sensing, communications, and software technologies supported by education and support programs for farmers.
- Changing the operating arrangements in irrigation systems so that farmers can request when they want water to suit their needs, as opposed to having to take water at a time that suits the underlying distribution infrastructure and the canal system operator's needs.

- Automation of canal systems and on-farm distribution systems to optimize the operation of these systems with respect to water conservation (spill reduction) and customer service (efficiency of use), i.e., to provide water as close as possible to when farmers want it and to distribute the water without the wastage that is typically associated with manual operations.

On October 20, 2018, the Cabinet of Ministers of the Republic of Uzbekistan issued Decree No. 841 “On measures to implement national goals and objectives in the field of sustainable development for the period up to 2030,” which defines national goals and objectives in the field of sustainable development for the period up to 2030, with target 2.4 on the introduction of agricultural methods that will increase agricultural productivity. Goal 6 states that by 2030, all sectors of the economy will have greatly improved water efficiency (target 6.4).

It is widely documented that the irrigation systems in Uzbekistan have poor water use efficiency and, as a direct implication, there are widespread salinity problems, threatening the sustainability of the sector. The poor efficiency of water distribution is essentially due to poor control, i.e., much more water is taken into the system than is required to match plant needs. This surplus water ultimately finds its way into the drainage system as either a direct spill from the supply canals or runoff from farm fields due to excessive application or from deep percolation from the fields and canals, which may require pumping from drainage wells. Much attention has been given to the lining of canals to reduce infrastructure losses, but the significance of these losses in the overall water balance does not appear to be known with certainty.

Taking into account the variety of conditions for conducting agricultural activities in Uzbekistan, it is planned to move from attempts to create a universal model for managing water facilities (operation and maintenance of water facilities, including irrigation and drainage networks, water distributors, pumping stations, etc.) to more flexible and diverse mechanisms.

In 2019, the “Strategy for the Development of Agriculture of the Republic of Uzbekistan for 2020–2030” was approved, which covers the following strategic priorities: ensuring food security of the population; creating a favorable agribusiness climate and value chains; reducing the role of the state in managing the sector and increasing investment attractiveness; ensuring the rational use of natural resources and environmental protection; development of modern systems of public administration; phased diversification of public spending in support of the sector; development of science, education, information, and consulting services in agriculture; rural development; and the development of a transparent system of industry statistics.

According to the ongoing reforms in the republic, the aim of improving water supply was determined by a plan to diversify water management using modern information and communication technologies. Expanding water-saving irrigation methods and maintaining the maintenance of irrigation and drainage infrastructure will improve the quality of land and cover water shortages.

On December 27, 2018, the President’s Resolution “On Urgent Measures to Create Favorable Conditions for the Widespread Use of Drip Irrigation Technology in the Production of Raw Cotton” was issued, which provides for the effective use of

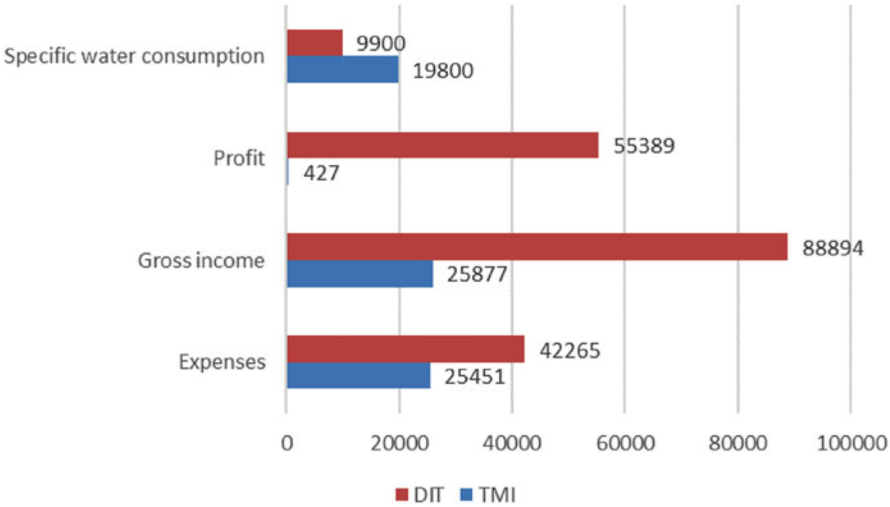

Fig. 3 Comparative analysis of the costs of farms for the production of raw cotton per 1 ha for 3 years with the traditional irrigation method (TMI) and with the use of drip irrigation technology (DIT). (Source: Data from the Ministry of Water Resources of the Republic of Uzbekistan for 2018, https://www.researchgate.net/publication/339999936_Ministry_of_Water_Resources_of_the_Republic_of_Uzbekistan_National_Committee_on_Irrigation_and_Drainage)

available water resources, the widespread introduction of innovative ideas, research developments, modern technologies, and scientific cotton growing areas using drip irrigation.

One of the important priority directions is the introduction of drip irrigation in many areas in the regions of the republic on farms. As the analysis showed, the use of drip irrigation technology (DIT) saves water several times more than the traditional method of cotton irrigation (Fig. 3).

In particular, the specific water consumption for the production of raw cotton for 3 years per hectare with the use of drip irrigation technology is 20 times less than the water consumption used for traditional irrigation. The economic effect of reducing water consumption for irrigation will amount to 446 thousand Uzbek sums per hectare or 5.8 billion Uzbek sums per 13 thousand hectares.

The costs of producing raw cotton with drip irrigation are almost 1.7 times higher than those for traditional irrigation, while more than 60% of the costs are the costs of introducing drip irrigation technology (purchase and installation of equipment). Despite the higher costs, the gross income of the farm from the production of raw cotton with the use of drip irrigation technology for 3 years exceeds the gross income with traditional irrigation by 3.4 times, and the profit is almost 130 times.

When using drip irrigation technology, farms incur lower costs for mineral fertilizers, seeds, mechanization, and fuels and lubricants. At the same time, the gross harvest of raw cotton from 1 hectare of land in 3 years with the use of drip irrigation is 5.6 tons more than with traditional irrigation. If the profitability of raw

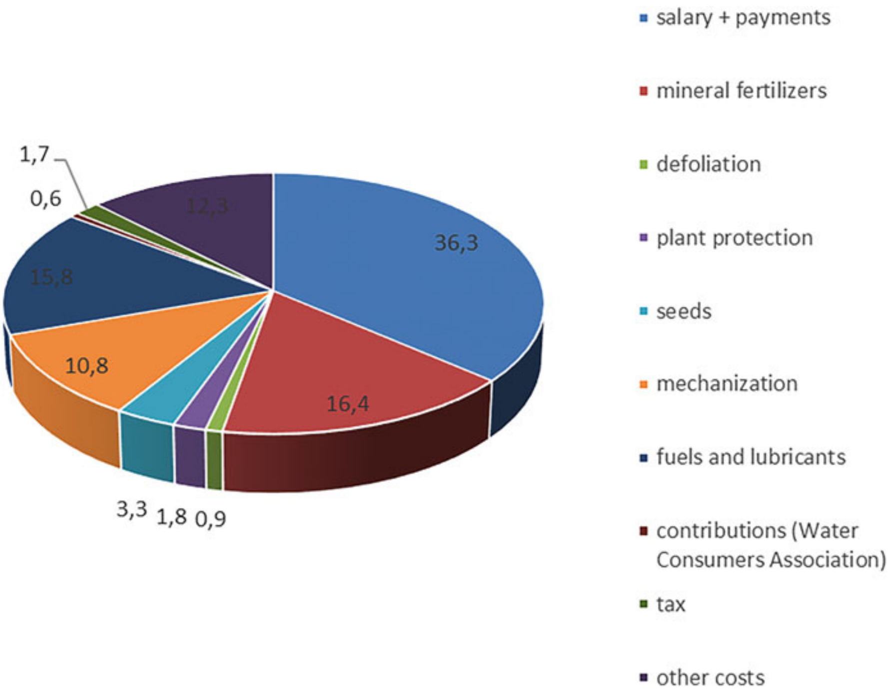

Fig. 4 Structure of costs for irrigation of raw cotton based on 1 ha under the traditional irrigation method. (Source: Data from the Ministry of Water Resources of the Republic of Uzbekistan for 2018, https://www.researchgate.net/publication/339999936_Ministry_of_Water_Resources_of_the_Republic_of_Uzbekistan_National_Committee_on_Irrigation_and_Drainage)

cotton production with traditional irrigation for 3 years is 1.7%, then with the use of drip irrigation technology, the production profitability reaches 131.1%. The first year of seed cotton production using drip irrigation technology will be unprofitable due to significant initial costs (profitability minus 8%). However, the second and third years will see high profits (profitability of 550.6% and 178.9%, respectively).

In the structure of annual costs of production of raw cotton with the traditional method of irrigation, the largest share is occupied by labor costs, followed by the costs of purchasing mineral fertilizers, fuels and lubricants, mechanization, and other costs (Fig. 4). When farmers use drip irrigation technology, significant savings in water, energy, labor costs, fuel, lubricants, and other materials are observed, as well as savings in mineral fertilizers of 30–40% (Fig. 5). There is a rapid and intense absorption of nutrients. The use of drip irrigation on the slopes does not create any threat of erosion (UNEP 2021).

Based on the average crop yields and average prices for them, the annual benefits were calculated. The total water savings for all crops is 11,760 m^3 of water per hectare of cotton, 6600 m^3 of wheat per hectare, and 11,455 m^3 of water per hectare of garden per year.

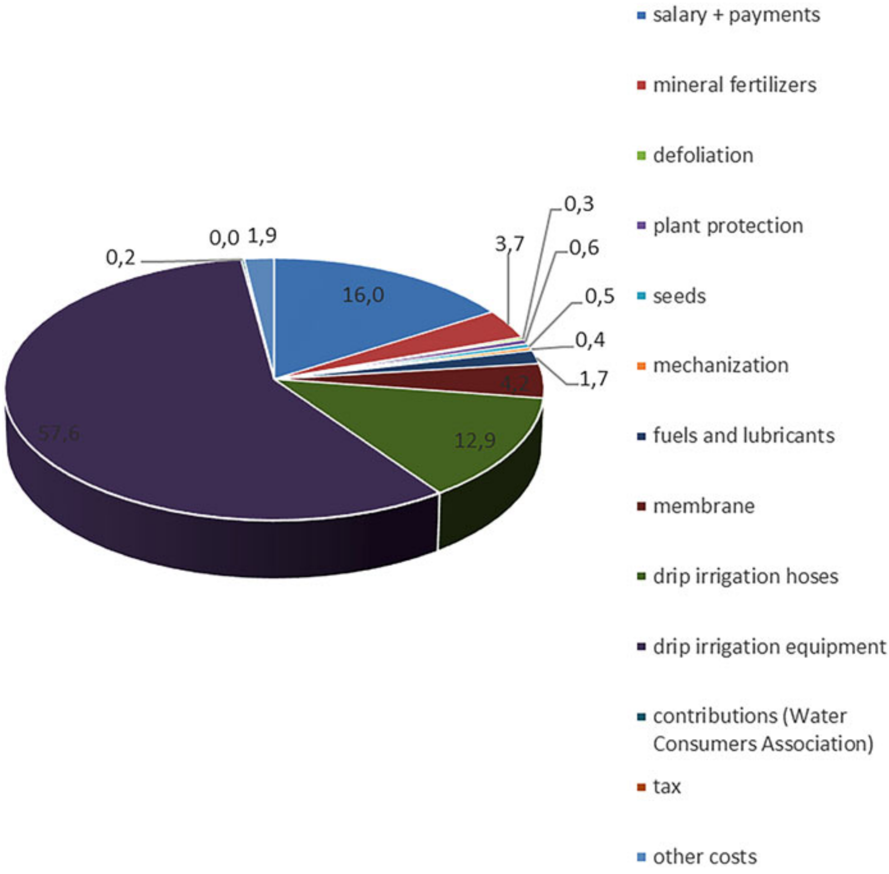

Fig. 5 Cost structure for irrigation of raw cotton based on 1 ha when using drip irrigation technology. (Source: Data from the Ministry of Water Resources of the Republic of Uzbekistan for 2018, https://www.researchgate.net/publication/339999936_Ministry_of_Water_Resources_of_the_Republic_of_Uzbekistan_National_Committee_on_Irrigation_and_Drainage)

According to the calculations, investments made in drip irrigation for cotton will pay off in just over 3 years and for wheat in 4 years.

Although a drip irrigation system will require an initial investment and some maintenance costs, the amount of water saved will be worth the effort, especially for small farms. Since watering is more targeted, focusing on the root system, plants can be watered less frequently without compromising on quality. Instead of watering daily, people who use drip irrigation find they can cut back on watering to a few times a week.

A drip irrigation system can be useful for many people, but it has several disadvantages. The nozzles in the system should be checked and cleaned regularly to prevent clogging. The fact is that the choice of dropper flow rate depends on the following:

- Mechanical composition of the soil
- A measure of salinity
- The level of standing groundwater
- The filtration capacity of the soil

Drip irrigation is convenient for small farms. When introducing the system into the conditions of large farms, errors during installation can result in a loss of yield of several thousand tons (UNEP 2021).

Tracing the history of the development of the irrigation network, it can be noted that irrigated agriculture originated in areas adjacent to natural waterways. The factors contributing to the development of irrigation in these areas were the proximity of water sources and relatively flat and large in area and length terrace surfaces covered with loess deposits. The soil cover formed on loess rocks is characterized by high fertility. In conditions of irrigation on these tracts, it is possible to obtain yields of all agricultural crops.

The Cabinet of Ministers approved an action plan for the modernization of hydraulic structures in a number of regions of the republic in cooperation with the Australian company Rubicon Water (Australia) for the installation of locks. Many regions of the republic will be simultaneously involved, in particular, the management of the South Fergana main canal and the North Fergana main canal, for a total of 246 thousand hectares of irrigated agricultural land in the Andijan, Fergana, and Namangan regions.

With the assistance of the Ministry of Water Resources, the Ministry of Energy, the Ministry of Finance, the Ministry of Development of Information and Communication Technologies, the Council of Ministers of the Republic of Karakalpakstan, and regional khokimiyats (local authority organs), it is planned to create an automated monitoring system for 2435 reclamation monitoring wells in the Republic of Karakalpakstan. From the beginning of 2021, work began to automate the management processes of the Mirishkor and Kamashi canals in order to improve the water supply of 6.2 thousand hectares of irrigated agricultural land in the Kasbinsky district of the Kashkadarya region.

The recently renovated Dustlik pumping station in the Guzar district of the Kashkadarya region was noted as an example. As a result of its modernization, the water supply of 11 thousand hectares of land has improved, operating costs have decreased from 300 million to 100 million Uzbek sums, and 8 million kilowatt hours of electricity are saved annually.

Systems to capture and inject drainage water back into the supply system have been developed to mitigate this poor control. While these systems do recover lost water, this comes at a cost as the quality decreases once the water enters the drainage system and energy is required to lift the water back into the supply system. Perhaps more problematically, flows in the drainage system are erratic, and this has a compounding effect on what is ostensibly a problem of poor control in the primary network due to manual operation. Furthermore, the cost of pumping water from the Amu Darya River is very high by global standards, even at subsidized electricity prices, due to the requirement to pump against substantial lifts. It is estimated that energy costs alone in the Kasbi system are approximately USD $25 per ml.

The recently published presidential decree defines a logical roadmap for reform by identifying the need for improved technologies, institutional reform, international collaboration, access to significant finance, and training and capacity development. An end-to-end architecture for implementing this roadmap is shown below.

Prior to undertaking any significant investment in infrastructure modernization, it is recommended that a detailed review of available data be undertaken to establish where the significant inefficiencies in the supply system occur. The mechanisms are as follows:

1. Operational spills from canvases.
2. Consumers are subjected to inaccurate metering.
3. Unauthorized use (theft).
4. System filling.
5. Seepage from canals (diffuse).
6. Leakage from canals (point source).
7. Evaporation.

Australia is very familiar with the impacts of water scarcity and drought, which, globally, are now high on the agendas of many government and business leaders. Water scarcity is a result of human activities exceeding the renewable, affordable supply of water in that region (Aither 2018).

Due to the similarities in the existence of arid areas in many regions of Australia and Uzbekistan, as well as the identities of the climatic conditions between both countries, it has led us to investigate the possible usage of the innovative technology of Rubicon Water (Australia) in the arid areas of Uzbekistan. The use of the Rubicon Water system in the arid regions of Australia has been successful. The technology was initially deployed on 3000 km of trunk canals in Victoria. Rubicon TCC has been selected to modernize and control 6800 km of open canal supplying water to 20,000 households. Farmers can order water, and it will be delivered within 2 h at a high and constant flow rate. The automated water supply system allows you to supply water from the sluices in liters. Modernization of this technology provides:

- Improved customer service
- Effective cleanup of spills
- Reduced lead time
- Flow rate that is constant
- Higher flow for optimal surface irrigation
- Elimination of counter-error
- Rationalization (removal) of some channels and counters
- Targeted canal lining using measurements from TCC and EM38 studies

The entire water supply process is controlled using solar panels installed at the water outlet from the sluices. The distribution efficiency of the canal system has increased by 20–25% and has been documented up to 95%, making water savings available for additional production or environmental protection (Rubicon 2021).

The delivery process is fully automated with additional benefits such as reduced labor costs, reduced transport and fuel costs, and increased safety of the process.

Water use is changing, finding its way to the most beneficial use and allowing new crops to be grown with increased returns from limited water, as evidenced by the significant changes in crops grown in the Murrumbidgee Irrigation Zone over the past 20 years. In Australia, 600 million USD annually comes from agricultural products.

IBM Automated Channel Systems monitor farm sensor networks, soil moisture, rainfall, evaporation, nutrients, and remote sensing crop inputs and outputs, improve weather forecast accuracy and resolution for the entire catchment area, and evenly distribute water flow to the field.

In the action plan for the digitization of water resources using modern information and communication technologies, it is planned to introduce the "Smart Water" system for operational control and accounting of water at 3099 gauging stations, as a means of accounting and controlling water consumption in the water management system.

The first step in the very successful modernization of the Australian irrigation sector was a desktop "water balance" study to estimate the significance of the seven loss mechanisms detailed above for the State of Victoria. A pilot implementation of Rubicon's Total Channel Control technology, involving 174 automated gates on a 1.4 m^3/s capacity canal, demonstrated the economic and technical feasibility of autonomous canal operation and quantified, with a high degree of confidence, the abovementioned loss mechanisms. This pilot clearly demonstrated that if the losses on this canal were representative of the whole system, then wide scale implementation was a sound investment. The next step was a larger implementation on a 12 m^3/s canal, to verify the ability of the automation solution to "scale." In parallel, automated gates were installed at key points in the network to establish a robust water balance at the secondary and tertiary canal level. As a result of these activities, the state government decided to automate the entire network and invest in complementary works such as canal lining and system rationalization. The other states followed, and the modernization of all the major systems in the Murray-Darling Basin is within reach. Interestingly, of the 6800 km of canal in the State of Victoria, lining has only been implemented on approximately 300 km. The extent of this lining work has been based on return on investment criteria.

The parallels with the Australian and Uzbekistan irrigation sectors are strong, as evidenced by the reference in Uzbekistan policy to the very successful Murray-Darling Basin salinity and drainage strategy. Reducing accessions to the groundwater was at the core of this strategy, initially with a focus on whole-farm planning, laser grading, and farmer education. This has subsequently been further refined by reducing canal spills and improving farm irrigation scheduling and application via automation.

At the moment, this project for the introduction of modern Rubicon Water technology has been implemented in Uzbekistan of Mirishkor and Kamashi canals

Fig. 6 Automation of management processes of Mirishkor and Kamashi canals. *The Kasbi district of Kashkadarya region, Uzbekistan*

in order to improve water supply in 6.2 thousand hectares of irrigated agricultural lands in Kasbi district of Kashkadarya region (Figs. 6 and 7).

The implementation mechanism includes the following goals:

- Formation of a list of water facilities by introducing the Smart Water system through a general inventory of water facilities
- Calculation of the types and types of work and the amount of funds required for the construction of "Smart Water" at water facilities
- Installation of "Smart Water" devices at water supply facilities and their connection to the server devices of the Ministry of Water Resources
- Introduction of an "online" water monitoring system at 1687 pumping stations under the Ministry of Water Resources
- Creation of an automated monitoring system of 2435 reclamation monitoring wells under the Ministry of Water Resources
- Automation of management processes of 16 large water facilities in cooperation with local contractors

The use of artificial intelligence installed in the program allows us to determine the water metering in real time and the process of water loss on dams and rivers and to receive transparent, timely, and accurate information.

The main technical measures to reduce greenhouse gas emissions are associated with the renewal of worn-out equipment and the reduction of energy consumption at pumping stations for pumping irrigation using energy-efficient pumps.

In terms of its productivity, the Rubicon Water system (Australia) will not only save water resources for irrigation but also further reduce agricultural land by 12–15%.

Fig. 7 Introduction of Smart Water system for real-time water control. *The Kasbi district of Kashkadarya region, Uzbekistan*

The similarity of climatic conditions and soil quality in agricultural fields of Uzbekistan with Australia makes it possible to successfully apply the proposed technology in some areas of the region.

In terms of its productivity, the Rubicon Water system will not only save water resources for irrigation but also further reduce agricultural land by 12–15%.

Rubicon Water system is based on eWater Source – Australia's National Hydrological Modelling Platform – that is designed to simulate all aspects of water resource systems to support integrated planning, operations, and governance from urban, catchment to river basin scales including human and ecological influences. Source accommodates diverse climatic, geographic, water policy, and governance settings for both Australian and international climatic conditions. Source provides a consistent hydrological and water quality modeling and reporting framework to support transparent urban, catchment, and river management decisions. A free public version of the Source has been developed for trans-boundary IWRM studies and research (Australian Water Partnership, Canberra, 2018).

All this is expected to lead to a more efficient use of land and water resources, an improvement in the quality and competitiveness of food products, an expansion of Uzbekistan's exports, and an increase in food security indicators in the country.

Despite some differences in the landscape of the area from the Murray-Darling Basin, the introduction of this innovative technology will be effectively and successfully used in the irrigation of agricultural fields. This will significantly reduce the climate change burden in the region.

Conclusions

Within the framework of adaptation to climate change with the aim of rational management of water and land resources in Uzbekistan, it is necessary to apply water-saving and resource-saving technologies for irrigation and irrigation regimes for agricultural crops and improve reclamation, soil conditions of irrigated lands, and their mutually related optimal combinations.

As shown by the analysis of the implementation of the leading drip irrigation practices on the territory of irrigated lands in Uzbekistan, it has led to a significant reduction in water losses.

The potential for improvement in Uzbekistan is enormous. Numerous implementations from around the world have demonstrated that system-based automation technology can transform the operation of large-scale irrigation systems, saving huge quantities of water and providing the surety of supply to justify complementary investments in farm automation systems. Given the significant cost of pumping water in the Amu Darya and Syr Darya basins, the return on investment is expected to be much greater than in many other global locations.

The modernization of irrigation systems and hydraulic structures using the innovative Rubicon Water system and the use of control systems operating on solar panels in some regions of the republic meets the requirements of a comprehensive program for the implementation of measures to control climate change.

With regard to institutional objectives, the aspects of climate change and their impact on agricultural production in the country are not given due attention, either at the level of national policy or on the part of farmers. The first task should be to raise awareness among relevant partner organizations about the expected impacts of climate change on agricultural water use and advise them on appropriate adaptation measures.

Cooperation with the EU/FAO proposed crop monitoring and yield forecasting project, which aims to establish an Early Warning System (EWS) to provide timely information on hazards and weather conditions.

Possible measures could include the following:

- Improvement of production technologies with an emphasis on efficient use of irrigation and rainwater

- Promotion of river basin approaches and practices for the protection, conservation, and management of land and water resources (water sources, soil protection in upper watersheds, grassland restoration, etc.)
- Identification of sources of funding for the implementation of activities
- Negotiations with foreign donor organizations and international financial institutions to identify the resources required for the implementation of automation processes
- Ensuring interaction with the community and stakeholders
- Organization of advanced training courses for specialists in the field of agriculture and water management on the use of automated systems and their management of these water facilities
- The provision of advisory services to political actors to improve the political and institutional environment and develop capacities for adaptation to climate change
- Facilitating the exchange of knowledge on climate change and agriculture between practitioners and policymakers

Perhaps it would be appropriate to create some kind of infrastructure to combat climate change. A dedicated development center is needed to coordinate services for scattered climate change risk mitigation projects, build partnerships, and leverage the synergy of fragmented actions of all interested donors in the country. The center can also operate the system digitally online.

It can be concluded that an increase in food shortages will be associated with limited land and water resources and projected climate change, in which irrigation rates will increase by 5–10% by 2030. While maintaining the current model of food, land, and water resources management, the deficit will continue to grow, the land quality will deteriorate, and the water supply will be reduced.

Solving the problems of land degradation requires applying water-saving and resource-saving technologies to irrigation and irrigation regimes for agricultural crops and improving reclamation regimes, soil conditions of irrigated lands, and their mutually related optimal combinations.

The goal is, of course, one: to solve the water problem and use water resources rationally. Reforms in agriculture are needed to improve water management in Uzbekistan. Among the reforms in the water sector of Uzbekistan, one can note such as limiting water use, step-by-step improvement of the legislative framework for water use, transition to the hydrographic basin principle of water resources management, improvement of land reclamation, diversification of crops, introduction of integrated water resources management (IWRM) and water-saving technologies, capacity improvement, large-scale investments in the development of innovative and accessible products and services responsive to climate change, etc.

- Introduction of modern water supply and irrigation systems applicable to the conditions of the Republic of Uzbekistan.
- Development of water desalination technologies. In some regions of the Republic of Uzbekistan, there is a high level of groundwater (e.g., in Central Kyzyl Kum).

In the case of the development of desalination technologies, groundwater can become the basis for a decentralized, autonomous fresh water supply system.
- Implementation of the successful experience of foreign countries in drip irrigation.
- Renovation of existing and construction of new irrigation and drainage infrastructure and widespread automation of management of agricultural complexes.
- Development and implementation of monitoring systems for the quantity and quality of consumed water and the qualitative composition of soils. This makes it possible to predict how much water will be available for each crop and how much water will go to a certain area in the future.
- Introduction of innovative technologies and approaches to create water-saving technologies, improvement of pastures, adaptation to climate change, etc.

Expanding water-saving irrigation methods and maintaining the maintenance of irrigation and drainage infrastructure will improve the quality of land and cover water scarcity.

In the near future, improving management, rationalizing use, and searching for internal reserves of water resources can meet the growing demand for water. The main task is to ensure the productive use of every drop of water in all areas of water use in order to reduce water consumption per unit of production or per physical consumer.

The implementation of these innovative technologies is expected to show local results that will be critical to the implementation of the agricultural water efficiency reform roadmap.

Deliberate state policy of the state, institutional reforms, and investments in the modernization of infrastructure, especially irrigation, will strengthen water security in the face of climate change and lead to the achievement of the sustainable development goals.

Cross-References

► Environmentally Sustainable Water Supply in Bangladesh: Rhetoric or Reality
► Farmers' Adaptation Strategies against Climate Change for Sustainable Development: Hazard-Prone Countries in Asia
► Indian Agriculture towards Mitigation of Climate Change
► Integrated Water Resource Management (IWRM) in Climate Vulnerable Areas of Bangladesh to Achieve SDG

References

Aither 2018 Water Guide: Setting a path to improved water management and use under scarcity, 2nd edn. 2018. p 72. ISBN 978-1-921543-32-6

Atlas of Sustainable Development Goals 2017. From world development indicators https://datatopics.worldbank.org/world-development-indicators/. Accessed 2017

Australian Water Partnership, Canberra. https://waterpartnership.org.au/wp-content/uploads/2018/03/18131-AWP-Water-Guide-Version-2.pdf. Accessed Mar 2018

Central Asia Water and Ecology Knowledge (2020). www.cawater-info.net

Decree of the Cabinet of Ministers of the Republic of Uzbekistan No. 841 “On measures to implement national goals and objectives in the field of sustainable development for the period up to 2030” dated October 20, 2018. https://lex.uz/ru/docs/4013358

FAO Report. Climate and environment https://news.un.org/ru/story/2021/08/1408882. Accessed Aug 2021

Mavlyanova NG, Rakhmatullaev KhL, Turaeva ST (2016) Land resources and food security of Central Asia and Southern Caucasus/Food and agriculture organization of the United Nations, Rome. ISBN 978-92-5-009329-1. FAO. Chapter 5. The degradation of the loess areas as result of intensive irrigation, pp 129–155

National report on the State of the environment and the use of natural resources in the Republic of Uzbekistan/State Committee of the Republic of Uzbekistan for Nature Protection. (2013). Chinor ENK, Tashkent, p 94. ISBN 978-9943-313-49-1

Niyazmetov D, Rudenko I (2018) Drip irrigation is a necessary reality for Uzbekistan. Economy and business. https://nuz.uz/ekonomika-i-finansy/35318-kapelnoe-oroshenie-neobhodimaya-realnost-dlya-uzbekistana.html

Open Data Portal of the Republic of Uzbekistan/Irrigated lands of the land fund of the Republic of Uzbekistan. https://data.gov.uz/en/datasets/10319. Accessed 2015

Ramazanov, A. (2019). Lessons of “extensive” development of irrigated agriculture in uzbekistan. Ways to improve the efficiency of irrigated agriculture (1):260–265.

Rashid Kulmatov Problems of Sustainable Use and Management of Water and Land Resources in Uzbekistan Journal of Water Resource and Protection, 2014, 6, 35-42 Published Online January 2014 (http://www.scirp.org/journal/jwarp). https://doi.org/10.4236/jwarp.2014.61006

Rubicon (2021) Water signs MOU with the Ministry of Water Resources of the Republic of Uzbekistan https://rubiconwater.com/us/rubicon-water-signs-mou-with-the-ministry-of-water-resources-of-the-republic-of-uzbekistan/

UNEP (2021) First Biennial Climate Change Report 2021 Center of the Hydrometeorological Service of the Republic of Uzbekistan. https://unfccc.int/sites/default/files/resource/FBURUzru.pdf. p 81

World Resource Institute (2019). https://www.wri.org/applications/aqueduct/country-rankings/. Accessed 2011