INVESTMENT AND FINANCIAL FLOWS (I&FF) ASSESSMENTS

TO ADDRESS CLIMATE CHANGE IN THE SECTORS:

ELECTRICITY, AGRICULTURE AND DRINKING WATER SUPPLY

Summary

Uzbekistan decided to carry out an assessment of Investment and Financial Flows (I&FF) to reduce emissions and to adapt to climate change in three key sectors of the economy (electricity, agriculture and drinking water supply).

The practical significance why this work was carried out is that no similar assessment had been conducted in Uzbekistan earlier yet. This work is rather a logical continuation of earlier studies conducted in this process, including: a national review of the regulatory framework, a portfolio of projects/programs implemented jointly with international environmental organizations; a mapping of sectoral investment programs and projects, evaluating the effectiveness of the results obtained.

In addition to the above, in order to prepare this report, a team of national experts has been trained in a special training to enhance national capacity in the field of I&FF assessments.

The **goal** of this study is to assess whether, in reality, the investment and financial flows in the economy of Uzbekistan contribute to an effective solution of the problems associated with climate change (challenges). To achieve this, in all three target sectors, based on the need for adaptation measures and measures to reduce emissions of pollutants into the atmosphere, the following ***tasks*** were completed:

- ✓ the boundaries of the sectors were defined. For example, in the social sector, the I&FF assessment focuses on drinking water supply;
- ✓ an analysis of historical investment and financial flows was carried out (the historical period was identified individually in each sector, depending on the availability of complete and reliable data);
- ✓ measures were identified to mitigate the effects of climate change as well as adaptation measures;
- ✓ sectoral scenarios: baseline scenario and adaptation/mitigation scenarios, which all consider climate change were developed;
- ✓ investment and financial flows were identified for the baseline scenarios and the adaptation/mitigation scenarios for the future (2017-2025);
- ✓ a comparative analysis of the measures has been done of the above scenarios;
- ✓ the feasibility (costs) of implementing the proposed activities was assessed.

According to the results of the assessments, the relevant conclusions were drawn that, in the implementation of the baseline scenario under consideration, where climate change is not being addressed, the environmental burden will increase and its negative consequences will not only affect the environmental situation, but will also have a multiplier effect on the socio-economic development of the country.

Based on these considerations, the authors proposed adaptation/mitigation scenarios, which envisage measures to address climate change. In addition, these scenarios take into account factors related to structural changes in the economy, development of industrial and social infrastructure, technological modernization of and physically obsolete facilities and others. The obtained results of the I&FF assessments show that the implementation of activities under the adaptation/mitigation scenarios in the sectors "Electricity" and "Agriculture" will contribute not only to limiting the negative effects of climate change, but also to have a positive impact in all spheres of human life. It should be noted that those activities aimed at adapting to climate change will also contribute to the successful implementation of innovative projects linked to the development of the "green economy".

With regard to the sector “Drinking water supply”, implementation of adaptation measures will not only significantly reduce the adverse effects of climate change, but also address an important social problem in providing the population with quality drinking water.

This research reveals the political consequences, first of all, regarding the issues of improving the legal framework and legislative acts in the field of water resources management in the social sector and the agriculture sector, as well as optimizing the ecological state of the environment in the Republic of Uzbekistan.

The experts also identified the main uncertainties related to the key sectors: Firstly, the lack of an officially approved concept for the development of renewable energy in Uzbekistan for the medium and long term, which would guide actions and predictions for mitigating climate change; second, the lack of a government program to develop a drinking water supply system in Uzbekistan until 2025.

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CHAPTER I. ASSESSMENT OF INVESTMENT AND FINANCIAL FLOWS (I&FF) TO ADDRESS CLIMATE CHANGE IN THE ELECTRICITY SECTOR

Introduction

It is expected that in future the deficit of traditional energy resources may be exacerbated, considering the current trend of energy consumption, and taking into account the modernization of the economy, structural transformations, modernization of the industry, population growth, as well as the forecasted average annual GDP growth rate.

Despite the measures taken in recent years to modernize the fuel and energy complex, the energy system of Uzbekistan remains vulnerable from the point of view of energy security, as it is based on generation in thermal power plants with a high share of natural gas (94%).[1]

In addition, the current pace of implementing measures for the modernization and technological upgrade of the fuel and energy complex does not correlate with the forecasts of the country's economic development, which can create a problem to guarantee energy supply to remote and hard-to-reach areas.

At the same time, the growing consequences of global climate change require countries to accelerate diversifying the structure of their generating capacities through the introduction of renewable energy sources (solar, wind, etc.). However, they currently do not replace traditional fuels in Uzbekistan.

According to the results of the most recent GHG inventory, the total greenhouse gas emissions in 2012 amounted to 205.2 million tons of CO2-eq.[2] The greatest amount of GHG emissions in 2012 falls on the energy sector with 81.9% (87% in 2004), which defines the industry as a key sector for reducing the energy intensity of the economy and limiting greenhouse gas emissions, and therefore being considered for an I&FF assessment.

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[1] The data of joint-stock company "Uzbekenergo". http://www.uzbekenergo.uz/en/activities/technical-and-economic-indicators/.

[2] The third National Communication of the Republic of Uzbekistan under the United Nations Framework Convention on Climate Change. Tashkent. 2016.

According to the Third National Communication data, in Uzbekistan for the period from 1951 to 2013, the warming rate (Δtemperature/10 years) averaged 0.27°C over 10 years. Predictions of global and regional climate change impacts across the territory of Uzbekistan are that by 2030 the possible increase in air temperature may reach 1-1.4°C.[3] Climate change is expected to lead in the future to an increase in water losses by 10-15% due to evaporation from the water surface and by 10-20% due to the increase in transpiration by plants, which will cause an increase in irretrievable water consumption by an average of 18% with a corresponding increase in water abstraction.[4] According to long-term forecasts, considering an extreme scenario of GHG emissions, the flow of individual rivers in the Amudarya river basin is expected to decrease by 7-22%, the Syr Darya river even by 5-42%.[5]

Therefore, serious impacts of global warming on the industrial sectors of Uzbekistan can be expected, including:

- a decrease in electricity production by hydroelectric power stations due to the limited water resources.
- an increased energy demand required for cooling systems of thermal power plants, machinery and equipment in the industrial sector. Climate change will affect the energy sources and technologies of electricity generation in different ways, depending on the resources used, technological processes and location (for example, coastal areas).[6]
- an efficiency decrease of distribution and transmission infrastructures. The temperature change reduces the energy transfer efficiency. If the temperature rises by 2°C, the transmission losses will increase by 0.05%, and the transmission power losses will increase by 3%.[7]

Thus, the implementation of adaptation and mitigation measures aimes at both diversifying energy sources and increasing the efficiency of its use, and is necessary to reduce the risks of significant losses for the economy and the social situation of the population.

The provision of significant resources and the development of renewable energy can be an important tool to ensure the country's energy security and to make a significant contribution in addressing climate change.

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[3] The third National Communication of the Republic of Uzbekistan under the United Nations Framework Convention on Climate Change. Tashkent. 2016.

[4] Abdusalamov D. "Strengthening the synergy effect of the national programs of the CIS countries on energy efficiency and energy conservation to improve their energy security" The national report on the Republic of Uzbekistan was compiled in the framework of the project of the United Nations Economic Commission for Europe. State joint-stock company "Uzbekenergo" 2013.

[5] The third National Communication of the Republic of Uzbekistan under the United Nations Framework Convention on Climate Change. Tashkent. 2016.

[6] Climate change, 2014. Impacts, adaptation and vulnerability. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Summary for politicians. WMO. UNEP. http://www.ipcc.ch/ Page 19.

[7] James Neumann. The Vulnerability of Energy Resources in the Context of Climate Change: A Regional Approach. Meeting of the ESCC. September 4-5, 2014 Beijing.

According to the Intented Nationally Determined Contribution of Uzbekistan to address climate change (INDC),[8] it is envisaged to reduce by 2030 the emission of greenhouse gases per unit of GDP produced by 10% compared to 2010. To achieve this goal, an attempt was made for the first time in Uzbekistan to assess the movement of investment and financial flows in the electricity sector, to determine their potential to reduce emissions and to fully meet the growing energy needs of the economy for the period 2017-2025.

The choice of the time period is a medium-term time period, during which investment and financial flows were assessed that are required to mitigate the effects of climate change. The assessment takes into account and is based on the current status and equipment, as well as technological capabilities of Uzbekistan.

[8] Intended Nationally Determined Contributions of the Republic of Uzbekistan (INDC) http://www4.unfccc.int/Submissions/INDC/%20Published%20Documents/Uzbekistan/1/INDC%20Uzbekistan%2018-04-2017_Eng_20170419093154_171926.pdf

1. Objectives

The assessment of investment and financial flows[9] in the electricity sector of Uzbekistan is designed to identify priority actions to mitigate the effects of climate change and to ensure sustainable development of the electric power industry in Uzbekistan in the future.

The main objective of this process is to identify and describe scenarios for the assessment of investment and financial flows in the electricity sector for the implementation of activities that can be implemented to reduce greenhouse gas emissions.

To achieve this goal, the following tasks have been accomplished in the course of the process:

- defining the boundaries and scope of the sector;
- analysing and assessing investment and financial flows in the energy sector for the historical period (2010-2016);
- determining measures to mitigate the effects of climate change in the energy sector;
- identifying future scenarios for the electricity sector (baseline scenario and mitigation scenario);
- defining investment and financial flows for the baseline scenario and for the mitigation scenario (2017-2025), taking into account the current situation of equipment and technological capabilities of Uzbekistan to mitigate climate change;
- conducting a comparative analysis of the above scenarios to determine the required changes and increases of investment and financial flows;
- evaluating the feasibility (costs) of implementing mitigation measures.

1.1 Justification

1.1.1. Previous Analyses Utilized

This work uses existing analytical material, reviews and publications to justify the actions and priorities in achieving the goal. Primary sources included:

- materials of international environmental conferences, seminars and meetings, the results of international and national projects, as well as the

[9] "Investment Flow" (IF) is the capital costs for the construction of new and modernization of existing power plants.
"Financial Flow" (FF) is the current costs associated with program activities for training personnel, the costs of conducting seminars, the dissemination of popular literature, the training of new personnel and the upgrading of skills of previously employed personnel.
"Operating and Maintenance Costs" (O&M) are operating costs, including: raw materials and materials, payment for water, production services, fuel, energy, payroll, social security, environmental fees, and others.

opinions and recommendations of international experts;[10]

- reviews of the national legal framework, existing/drafted national plans, concepts, strategies and programs, research projects and reports on energy conservation, mitigation and adaptation to the impacts of climate change in industry (energy), which have been prepared specifically for this process;
- analytical material identifying a specific investment plan of the Low-Carbon Development Strategy of the Republic of Uzbekistan for the field of industry (energy).

It was also important to consider that the economic policy of the Government of Uzbekistan in the medium and long term aims at:

- modernizing the technological equipment of the electric power industry, which will make it possible to make full use of available reserves to increase the energy efficiency of generated electricity and to ensure high rates of economic growth;[11]
- reducing energy intensity and resource intensity of the economy, introduce energy-saving technologies into production in a widespread manner, expanding the use of renewable energy sources, increasing labor productivity in the sectors of the economy.[12]

1.1.2 Institutional Arrangements and Collaborations

To carry out the steps of the I&FF assessment, institutional arrangements and collaboration mechanisms between various organizations were discussed. Intersectoral meetings were held, involving ministries, departments, organizations and scientific research institutes of the Republic of Uzbekistan, in which national experts contributing to the assessment participated. Representatives of the following organizations and institutions took part in intersectoral meetings:

- The Center for Economic Research under the service for the Coordination of Social and Economic Policy of the Office of the President of the Republic of Uzbekistan;
- The Ministry of Economy of the Republic of Uzbekistan;
- The joint-stock companies "Uzbekenergo" (generating and supplying

[10] Conducted in Tashkent in 2017 a series of seminars on the criteria for assessing investment and financial flows, and meetings with experts of Uzhydromet, as well as national experts with specialists of Uzbekenergo within the framework of the program of preparation of Uzbekistan for access to resources of the ZKF (UNDP), support of national plans on adaptation to climate change (USAID).

[11] Report of the First President of the Republic of Uzbekistan IA. Karimova at an expanded meeting of the Cabinet of Ministers dedicated to the results of the socio-economic development of the country in 2015 and the most important priority areas of the economic program for 2016. The report predicts an increase in the volume of gross domestic product by at least 2 times by 2030, while reducing the energy intensity of GDP by about two times.

[12] Decree of the President of the Republic of Uzbekistan No. UP-4947 of 07.02.2017 "On the strategy of actions for the five priority development directions of the Republic of Uzbekistan in 2017-2021".

electric power in Uzbekistan)[13] and "Uzbekhydroenergo" (comprising hydroelectric power stations, hydrotechnical and other hydropower related units of UzbekEnergo);[14]

- The Committee of Hydrometeorology under the Cabinet of Ministers of the Republic of Uzbekistan;
- International Financial Organizations (World Bank).

1.1.3. Basic Methodology

The methodology to carry out an I&FF assessment for the implementation of activities in the electricity sector of Uzbekistan to address climate change includes the following steps:

1. Establishing key assessment parameters. This I&FF assessment focuses on the electricity sector, which is the main source of greenhouse gas emissions and environmental pollution in the generation of electricity.[15] The choice of this sector is determined by the priorities of the economic policy of the Republic of Uzbekistan regarding measures to mitigate climate change.[16] At the same time, the boundaries of the electricity sector for the I&FF assessment are determined by the national conditions, priorities and characteristics of the current electricity generation system in Uzbekistan, the nature and diversity of the projected climate change impacts on the sector, the availability of specific information on the current situation and trends for the sector.

The assessment used information:

- on the measures of the electricity sector, characterizing the state, efficiency of electricity generation[17] and long-term plans for new construction and modernization of generating capacities;
- from annual reports of power plants: the amount of electricity generated, the specific cost of conventional fuel for generating 1kWh of electricity, the operating time of power units, the technical characteristics of the main equipment of power plants, the operating costs of power plants, the amount of fuel consumed, the associated I&FF;
- on the volume of investments for the implemented, as well as planned activities that were needed to establish a record of historical and future data;
- on the required norms of specific capital investments for the construction and reconstruction of electric power facilities.

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[13] http://www.uzbekenergo.uz/en/

[14] http://tashkenttimes.uz/national/959-president-signs-decree-creating-uzbekhydroenergo

[15] The third National Communication of the Republic of Uzbekistan under the United Nations Framework Convention on Climate Change. Tashkent. 2016.

[16] These measures are associated with the priority areas of the Action Strategies for the five priority development areas of the Republic of Uzbekistan in 2017-2021; Decree of the President of the Republic of Uzbekistan No. ПП-3012 of 26.05.2017. "On the Program of Measures for the Further Development of Renewable Energy, Improving Energy Efficiency in the Spheres of the Economy and the Social Sphere for 2017-2021".

[17] For each of the proposed projects, the fuel economy is determined, which is then multiplied by the CO_2 emission factor from the combustion of this fuel.

I&FF assessments were carried out using direct calculation methods, extrapolation of trends and time series, econometric models, expert assessments and other analysis and forecasting tools.

As a basis for the methodological approach, the regulatory framework was reviewed, the actions taken by the Government were considered, as well as previously prepared documents and material on mitigating climate change were taken into consideration. Especially the following official documents were used:

- The Strategy of Actions for the five priority development directions of the Republic of Uzbekistan in 2017-2021;[18]
- The National Action Plan for the Protection of the Environment and the Environment of Uzbekistan for 2017-2021;
- The Third National Communication on the United Nations Framework Convention on Climate Change ", UzHydromet, Tashkent, 2016;
- Identified adaptation measures in Uzbekistan for the period up to 2030;[19]
- Statistical data from the State Statistics Committee of the Republic of Uzbekistan on the socio-economic development of the Republic of Uzbekistan, including investments in non-financial assets for 2010-2016;
- Reports of the joint-stock companies "Uzbekenergo" and "Uzbekhydroenergo" on the production and economic activities for 2010-2016;
- Information of the joint-stock companies "Uzbekenergo" and "Uzbekhydroenergo" on the implementation of scheduled measures for the further development of renewable energy, improving energy efficiency in the economic and social sectors for 2017-2021;[20]
- UNDP methodological handbook for assessing investment and financial flows to address climate change.[21]

2. Defining the baseline scenario. In this step, a the trends of th sector are being identified, considering that the current development will continue, describing what can happen in this sector in the absence of additional measures related to climate change. The analysis of the baseline scenario development takes into account the expected trends in the change of key factors (the service life of the power generating equipment, the specific consumption of fuel equivalent per unit of electricity generation etc.), which have a significant impact on the development of the sector. Within this scenario, this relevant data was integrated and the annual I&FF were identified. For the baseline scenario, a number of assumptions were made about the most likely development in these factors.

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[18] Decree of the President of the Republic of Uzbekistan No. UP-4947 of 07.02.2017.

[19] Uzbekistan's INDC report: http://www4.unfccc.int/Submissions/INDC/Published%20Documents/Uzbekistan/1/INDC%20Uzbekistan%2018-04-2017_Eng_20170419093154_171926.pdf, presented to the UNFCCC, April 2017.

[20] Resolution of the President of the Republic of Uzbekistan No. ПП-3012 of 26.05.2017.

[21] Methodological handbook on the evaluation of investment and financial revenues for addressing climate change issues, 2009, UNDP, 2009.

3. Defining the mitigation scenario and determining required changes of I&FF. The mitigation scenario considers the implementation of new climate change mitigation policies and measures during the assessment period. The measures are based on those measures stipulated in the Action Plan on Climate Change Mitigation and Adaptation (of the INDC), as well as the Strategy of Action for the five priority development directions of the Republic of Uzbekistan in 2017 - 2021.

Implementation of measures for increasing energy efficiency in various sectors of the economy and the social sphere. At the same time, the policy measures related to mitigating climate change in the electricity sector are considered in the context of population growth, sustainable economic growth, as well as future demand for electricity and energy efficiency. In this step, the necessary changes and increases in I&FF to implement mitigation measures were identified.

4. Conducting policy impact assessments. This step of the methodology analyzes the incentives of key ministries, departments and relevant organizations to implement the proposed measures and to provide the required I&FF that have been identified. The I&FF process provides for the organization of consultations with all relevant parties policy measures such as normative acts or incentive measures needed as an instrument for inducing the required investments. When considering the results of the I&FF assessment of the electricity sector, it is also important to qualitatively assess economic, social and environmental benefits.

2. Sector Scope: Energy Efficiency

2.1. State of the Electricity Sector

The power generation sector of Uzbekistan, as a basic industry, is characterized by:

- a close relationship of the sector with all sectors of the country's economy in meeting their electricity needs;
- a significant share of the electricity sector in the consumption of primary energy resources and greenhouse gas emissions, which confirms its priority in implementing measures to mitigate climate change;
- a high share of greenhouse gas emissions attributable to the energy sector: 81.9% (87% in 2004),[22] which confirms its importance in implementing measures to mitigate climate change.

The total generated capacity of power plants in the electricity generation sector is 14.2 thousand MW, with an annual output of 58.6 billion kWh of electricity (Table 1).

Table 1. Capacity structure of power generation (2016)

	MW	%
Total	**14164.00**	**100.0**
Thermal power plants	12370.00	87.3
Hydropower plants	1794.00	12.7
Solar	0.13	0.001
Wind	0.00	0.0

Source: Resolution of the President of the Republic of Uzbekistan No. PP-3012 of 26.05.2017.[23]

The basis of the power industry of Uzbekistan is formed by 10 large thermal power plants with an installed capacity of 12.4 MW[24] (2016), which provide 87.3% of electricity production. Among them are: Navoi Thermal Power Plant with a capacity of 1540 MW (electricity generation: 9.2 billion kWh per year), Tashkent Thermal Power Plant with a capacity of 1860 MW (electricity generation: 7.9 billion kWh per year), Talimarjan Thermal Power Plant with a capacity of 2,600 MW (electricity generation: 7.2 billion kWh per year). The estimated capacity of thermal power stations for electricity generation using gas is 73%; the capacity of thermal power stations for electricity generation using solid fuel (fuel oil, coal) is 27%.

[22] The Third National Communication of the Republic of Uzbekistan under the United Nations Framework Convention on Climate Change. UzGidromet, Tashkent. 2016.

[23] Resolution of the President of the Republic of Uzbekistan No. PP-3012 of 26.05.2017. "On the Program of Measures for the Further Development of Renewable Energy, Improving Energy Efficiency in the Spheres of the Economy and the Social Sphere for 2017-2021".

[24] Resolution of the President of the Republic of Uzbekistan No. PP-3012 of 26.05.2017. "On the Program of Measures for the Further Development of Renewable Energy, Improving Energy Efficiency in the Spheres of the Economy and the Social Sphere for 2017-2021".

In addition, there are 32 Hydroelectric Power Plants operating in the country with a total installed capacity of 1.79 MWh[25] providing 9.3% of the country's electricity production. Among them are: the Cascade of Sredne-Chirchik hydroelectric power plants with a capacity of 1031 MW (power generation 3.5 billion kWh per year), the Chirchik Hydroelectric Power Plant Cascade with a capacity of 190 MW (power generation 1.1 billion kWh per year), Tuyamuyanskaya with a capacity of 150 MW, and Andijan with a capacity of 140 MW (Table 2).

Table 2. Structure of electric power production

	Name of the stations	2010	2016
	Thermal power plants	**83.8**	**87.3**
1	Syrdarya Thermal Power Plant	28.3	28.9
2	Navoi Thermal Power Plant	14.2	15.7
3	Talimarjan Thermal Power Station	10.7	11.8
4	Novo-Angren Thermal Power Plant	10.5	11.5
5	Tashkent Thermal Power Plant	11.7	11.1
6	Takhiatash Thermal Power Plant	5.9	5.4
7	Angren Thermal Power Plant	0.9	1.2
8	Fergana Thermal Power Plant	0.9	0.5
9	Mubarek Thermal Power Plant	0.6	0.5
10	Tashkent Thermal Power Plant	0.3	0.6
	Hydropower plants	**12.6**	**9.3**
1	Cascade of Sredne-Chirchik Hydropower Plant	7.8	5.9
2	Cascade of Chirchik hydroelectric power stations	2.4	1.9
3	Cascade of Kadyria hydroelectric power stations	0.6	0.5
4	Cascade of Nizhne-Bozsu hydroelectric power stations	0.3	0.2
5	Farhad Hydropower Plant	1.1	0.5
6	Cascade of Tashkent hydropower plants	0.4	0.3
	Other stations	**3.6**	**3.4**
	Total production	**100.0**	**100.0**

Source: Joint-stock company "Uzbekenergo"

The potential of solar energy in the Republic is practically not used. In 2016, solar power generation amounted to only 0.13 MW, or 0.001% of the total capacity of the electric power industry. At the same time, the gross potential of renewable energy sources (solar, wind, etc.) in the country is estimated at about 51 billion tons of oil equivalent.[26] About 97% of this potential falls on solar energy (0.13 MWh).[27] According to experts, the wind energy potential is

[25] Resolution of the President of the Republic of Uzbekistan No. ПП-3012 of 26.05.2017. "On the Program of Measures for the Further Development of Renewable Energy, Improving Energy Efficiency in the Spheres of the Economy and the Social Sphere for 2017-2021".

[26] Center for Economic Research. Analytical report. Alternative energy sources: opportunities for use in Uzbekistan. Tashkent, 2011.

[27] Decree of the President of the Republic of Uzbekistan of May 26, 2017 No. PP-3012 "On the program of measures for the further development of renewable energy, improving energy efficiency in the economic and social sectors for 2017-2021".

estimated at 2.22 million tons of oil equivalent/year.[28] Within the framework of the State Programme on Priorities for the Development of Industry of the Republic of Uzbekistan in 2011-2015[29] (2010) and the Programme for Priority Development of the Electric Power Industry for 2011-2015, developed by the joint-stock company Uzbekenergo (2010), projects and measures were taken to attract investments and expansion, modernization and construction of new power units worth about US$3 billion with the involvement of funds from International Financial Organizations.

As a result of the implementation of investment projects, additional capacity for the production of electric power for 2300 MW is provided.[30] In particular:

1. Three power plants commissioned new power units based on Combined-Cycle Plants: Navoi Thermal Power Plant (476 MW, introduced in 2012), Tashkent Thermal Power Plant (370 MW, introduced in 2015), Talimarjan Thermal Power Plant (900 MW, introduced in 2016). The efficiency factor for generating electric power on the basis of Combined-Cycle Plants at these Thermal Power Plants has been increased to 40-50% or more, compared to 35% earlier. At these thermal stations, the specific consumption of natural gas was significantly reduced from 0.4 to 0.28 m^3 for 1 kWh of energy produced, due to the introduction of capacities with Combined-Cycle Plants.

2. The cogeneration gas-turbine technology was put into operation at the open joint-stock company "Tashkent Heat and Power Plant" (27 MW, with a component under the Clean Development Mechanism, introduced in 2013), which allows increasing electricity generation by almost 228 million kWh, bringing the total annual output to 400 million kWh. At the same time, the gas consumption at the Combined Heat and Power Plant was reduced by 39 million m^3.

3. Expanders have been installed at the Syrdarya and Talimarjan Thermal Power Plants (20 MW) in order to increase the energy efficiency of the stations, enabling them to generate environmentally friendly electricity without using fuel and to save natural gas in the equivalent amount of this generated electricity.

In general, the impacts of the implementation of investment projects for the expansion, modernization and construction of new generating capacities based on resource-saving technologies in 2011-2015 included - along with the increase in the capacity of thermal power stations:

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[28] The Third National Communication of the Republic of Uzbekistan under the United Nations Framework Convention on Climate Change. Tashkent. 2016. Defined from a database of long-term meteorological observations (over 10 years) at 88 meteorological stations in Uzbekistan.

[29] Resolution of the President of the Republic of Uzbekistan as of 15.12.2010 No. PP-1442. The program provides for the implementation of 54 investment projects in the electric power industry for a total of more than US$7 billion during 2011 and 2015.

[30] Resolution of the President of the Republic of Uzbekistan as of 15.12.2010 No. PP-1442.

- A reduction of the specific fuel consumption for electricity generation from 379.8 g/kWh (2010) to 375.8 g/kWh (2016);[31]
- A reduction of greenhouse gas emissions in the energy sector in terms of generating 1 kWh of electricity from 3.16 kg of CO_2 (2010) to 3.10 kg of CO_2 (2016);[32]
- An increase of the reliability of uninterrupted power supply to enterprises, housing, social and household infrastructure of settlements.

As part of the measures taken to develop hydropower, four small hydropower stations were put into operation: Andijan-2, Akhangaran (2010), Gissarak (2011) and Ertaszyskaya (2013).[33] The hydrogenerators at Charvak Hydroelectric Power Plant were modernized through the replacement of impellers (three units, in 2015), which allowed to increase the capacity of the station by 45 MW.[34]

As a result of implementing the state energy saving policy for 2011-2016, the electricity intensity of Uzbekistan‘s GDP has decreased by 1.4 times.

2.2 Regulatory and Legal Framework of the Sector Electricity

The normative legal basis for implementing measures to address the global problem of mitigating climate change in the energy sector of Uzbekistan are the laws and regulations that regulate the implementation of measures to reduce greenhouse gas emissions and to mitigate the effects of climate change. These form the basis for the programs for the development of strategic industries, energy and resource saving and effective use of the attracted investment resources, as set out in the review of the main aspects in the area of emission reductions: "Development of induastial sectors in the context of mitigation and adaptation to climate change impacts. Energy Sector".

The Constitution of the Republic of Uzbekistan (1992) provides for special articles on the careful attitude towards the environment, on the rational use of natural and energy resources, on the responsibility for causing damage to the ecological environment, which creates a legal basis for the development and adoption of other laws. In particular for the Laws On the Protection of Atmospheric Air (1996), On Rational Use of Energy (1997), and On Electric Power (2009).

An important contribution to the improvement of the legislative framework, regulating measures in the field of energy and resource saving, development of national and sectoral programs of Uzbekistan is made by:

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[31] Data of joint-stock company "Uzbekenergo".
[32] Authors' calculations.
[33] Resolution of the Cabinet of Ministers of the Republic of Uzbekistan No. PCM-476 of 28.12.1995 "On the development of small hydropower in the Republic of Uzbekistan".
[34] Resolution of the President of the Republic of Uzbekistan as of 15.12.2010 No. PP-1442. "On the priorities of development of the industry of the Republic of Uzbekistan in 2011-2015".

- The National Sustainable Development Strategy of the Republic of Uzbekistan (1999);
- The First National Communication of the Republic of Uzbekistan under the UNFCCC (1999),[35] the Second National Communication on the UNFCCC (2008) and the Third National Communication (2016);
- Activities of the National Commission on Climate Change of the Republic of Uzbekistan, established in 1995, related to the UN Framework Convention;
- Government Decrees and Regulations defining Clean Development Mechanism policies; production, transmission and consumption of energy; and implementation of investment projects, which reduce the specific consumption of hydrocarbon fuels in electricity generation and reduce harmful emissions. In particular, in accordance with the approved regulation "On the procedure for preparation and implementation of investment projects under the Clean Development Mechanism of the Kyoto Protocol",[36] basic rules for the implementation of the Clean Development Mechanism in Uzbekistan are defined.

In addition, the Government of Uzbekistan adopted other special regulations, regulating norms and rules for reducing energy intensity and introducing energy-saving technologies. In particular, the Regulation on the Republican Commission on Energy Efficiency and Development of Renewable Energy Sources (PKM 238) was adopted, which defines the directions of activities, tasks, rights and functions of the Republican Commission.

2.3 Opportunities of Energy Efficiency

The introduction of new energy-saving technologies is an important part of the economic policy of the Government of Uzbekistan aimed at increasing the efficiency of electricity generation, including mitigation of climate change.

During 2010-2016 the country carried out large-scale work on the introduction of innovative technologies in the production of electricity (Combined-Cycle Plants), in the transmission of heat and electricity through networks, in the processing of electricity and natural gas, in the introduction of renewable energy sources etc. It was envisaged to implement measures to transform existing energy assets into more efficient assets with Clean Development Mechanism components, including funds from international organizations, climate change funds and low carbon financing.

[35] Prepared under the GEF/UNDP project "Uzbekistan-country study on climate change Phase 1 and Phase 2".

[36] Approved by Resolution of the Cabinet of Ministers of January 10, 2007 No. 9 "Regulations on the procedure for preparation and implementation of investment projects under the Clean Development Mechanism of the Kyoto Protocol".

As a result, the specific consumption of conventional fuel for the production of 1 kWh of electricity fell from 379.8 g/kWh to 375.8 g/kWh (Table 3), and electricity consumption for operation and maintenance went down from 5.8% to 5.6%.

In general, for the period 2011-2016, the savings in conventional fuel amounted to 193 thousand tons, which is equivalent to reducing greenhouse gas emissions in the amount of 306.8 thousand tons CO_2-eq.

However, despite the measures taken, the value of these indicators continues to be high. This is due to the fact that more than 70% of power plants have operated for more than 30 years, which exceeds the normative terms of their operation.

In the technological structure of installed capacity at thermal power plants, the share of capacities with Combined-Cycle Plants is less than 9.5% (2016). At the same time, the specific consumption of conventional fuel for electricity supply at Combined-Cycle Plants is 25% lower than for gas turbine plants (Table 4).

Table 3. Energy efficiency measures of thermal stations

Name of the enterprise	Specific consumption of conventional fuel for electricity generation, g/kWh		Emissions of GHG per 1 kWH of generated electricity, g/kWh		Decrease (-)/ increase (+) of GHG emissions per 1 kWh of generated electricity, g/kWh	Saving (-)/surplus (+) of fuel equivalent, thousand tons	Decrease (-)/ increase (+) of GHG emissions, thousand CO_2-eq
	2010	2016	2010	2016		2011-2016	
Syrdarya Thermal Power Plant	367.0	366.5	583.5	582.7	-0.8	-9.9	-15.7
Novo-Angren Thermal Power Plant	404.4	418.5	643.0	665.4	22.4	8.6	131.3
Tashkent Thermal Power Plant	40.9	426.0	639.1	677.4	38.3	162.4	258.1
Navoi Thermal Power Plant	416.0	374.3	661.5	595.2	-66.3	-380.5	-605.0
Takhiatash Thermal Power Plant	423.7	444.4	673.6	706.6	33.0	69.8	110.9
Angren Thermal Power Plant	446.1	407.1	709.3	647.4	62.0	-13.2	-21.0
Fergana Thermal Power Plant	212.2	198.8	337.3	316.1	-1.3	-4.1	-6.5
Mubarek Thermal Power Plant	153.0	159.0	243.3	252.7	9.5	1.9	3.1
Tashkent Thermal Power Plant	176.8	163.3	281.2	259.7	-21.5	-0.9	-1.4
Talimarjan Thermal Power Plant	317.0	306.3	504.0	487.0	-17.1	-71.6	-113.8
Total Thermal Power Plants	**2956.3**	**3264.2**	**5275.8**	**5190.2**	**58.2**	**-237.5**	**-260.0**

Source: Calculations based on data of the joint-stock company Uzbekenergo

Table 4. Structure of capacities in power plants by types of generating equipment (2016)

№	Electrical equipment	Power, MW	% of total	Specific consumption of conventional fuel for electricity supply, g/kWh
1	Combined-cycle plants	1350.0	9.5	286.0
2	Gas turbine plants	8920.0	63.0	379.0
3	Solid fuel turbines	2100.0	14.8	420.0
4	Hydroelectric units	1793.9	12.7	X
5	Solar installations	0.1	0.0	X
	Total:	**14164.0**	**100.0**	**375.8**

Source: Joint-stock company "Uzbekenergo"

In the structure of primary fuel used for the production of electricity and heat, natural gas continues to dominate with a share of 94.1%, the share of coal is 4.9%. (Table 5).

Table 5. Structure of primary fuel used in heat power plants

Name	2010	2016
Total	**100.0%**	**100.0%**
Gas	94.1%	94.1%
Fuel oil	2.0%	0.7%
Coal	3.7%	4.9%
Underground gas	0.2%	0.2%
Petrocoke	0.0%	0.1%

Source: Joint-stock company "Uzbekenergo"

The share of fuel and energy in the cost of electricity production is 55% (2015).[37]

Among the existing technical potential, hydropower is used providing only 12.7% of electricity production, and the potential of solar and wind power is practically not used. At the same time, the electricity intensity of the country's GDP is 1.5 times higher than the world average.

These performance indicators of the electricity sector allow to conclude that there is a significant potential for energy saving in Uzbekistan. Therefore, addressing the issues of increasing the energy efficiency of electricity generation will save significant volumes of fossil fuels (natural gas) and thereby reduce greenhouse gas emissions into the atmosphere.

[37] Industry of Uzbekistan, Statistical compendium, State Statistics Committee of the Republic of Uzbekistan, Tashkent 2016.

3. Data Input

3.1. Assessment Period and Cost Accounting Parameters

The I&FF assessment was conducted for a time horizon of 2010 to 2025. The base year is 2016. Data for the I&FF assessment characterize both the current state and prospects for the development of the sector, the direction of capital investments (investments in capital construction, including new construction, modernization, expansion and reconstruction), as well as current and future operating costs.

For some missing data of investment and financial flows between 2010-2016 and to establish the scenarios for 2017-2025, methods of expert assessments and data extrapolation were used.

3.2. Analytical Approach

The following methodical approaches were used in assessing the I&FF of the "Power Utilities" sector:

1. Phased analysis, considering:
    - the condition of equipment of power plants, the requirements for their operation, capacities and technical parameters of their operation;
    - worldwide experiences in the operation of power plants for transferring from gas turbine power plants towards combined-cycle plants, as well as towards the construction of new energy-efficient power plants;
    - causes of low energy efficiency of the power units and measures to increase their energy efficiency;
    - opportunities and conditions for the introduction of renewable energy sources and planned measures for the construction of power plants using solar and wind energy.

2. Calculations of electricity generation, specific primary fuel consumption, saving of primary energy resources and greenhouse gas emissions, as well as projection of I&FF for the period from 2017 to 2025 based on the construction and modernization of power plants; based on the development programs of the electric power industry of Uzbekistan for the period up to 2021 as well as expert proposals, from 2022 to 2025.

3. Operation and Maintenance costs (O&M) for 2017-2025 were determined by extrapolating linear trends based on data for 2010-2016, taking into account changes in fuel costs, as well as increasing costs for repair and maintenance of newly commissioned equipment.

4. A baseline scenario was developed, based on the premission that

implementation of investment projects, modernization and build new generating capacities would continue, in accordance with existing government decisions.

5. In addition to the baseline scenario, a target scenario for mitigating climate change was developed, which takes into account the implementation of specific activities to reduce climate change on and its impacts on sustainable electricity generation in 2017-2025. This served as the basis for determining the additional required investment and financial flows necessary for the implementation of activities.

During the calculation of electricity generation data, methods of econometric analysis were used. For example, the regression equation that identifies the dependence of hydroelectric power plant's generation according to air temperature change is based on the fact that the serious impact of global warming on Uzbekistan's hydropower sector is expected to reduce the production of electricity in the long term in, because it is projected that the country's hydropower potential will be reduced.

To construct an econometric model, the data period for 2000-2016 was selected for the generation of electric power by hydroelectric power stations (in billion kWh) along with the average annual air temperature in Uzbekistan (°C). According to the econometric analysis of the dynamic series of the above data, the following results were obtained:

1. The equation of linear regression is derived as:

$$y_1 = 28{,}822 - 1{,}659x_1$$

Where:
y_1 = function describing generation of electricity by hydroelectric power plants;
x_1 = independent variable (average annual air temperature).

2. The obtained results testify the negative impact of air temperature change on electricity generation, which confirms the above conclusions on reduced electricity generation as a result of an increasing average annual air temperatures.

3. According to the calculations of the regression equation, an air temperature increase in the Republic of Uzbekistan of 1°C may reduce electricity generation in hydroelectric power plants by 1.659 billion kWh; in other words, an increase in the average annual air temperature by 1% may result in a reduction in hydroelectric power production by 3.37%.

For comparison: According to the estimates of international experts, when the temperature rises by 2°C, the transmission losses will increase by 0.05%, and the loss of generating capacity will increase by 3%.[38]

[38] James Neumann. Vulnerability of energy resources in the context of climate change: a regional approach. Meeting of the ESCC. September 4-5, 2014 Beijing.

3.3. Historical IF, FF and O&M data

Historical I&FF data were prepared and processed for 2010-2016 from mapping materials and research work carried out during the historical period, conducted seminars, studying literature in the field of power systems development and investment estimates for the construction and modernization of generating capacities, as well as expert evaluations.

In particular:

- Fuel consumption data are derived from annual reports of power plants;
- Emissions of CO_2 equivalent were estimated for the combustion of each type of fuel (natural gas, coal, fuel oil, etc.);
- Required Investment Flows for the construction of new and modernization of existing power plant capacities are determined on the basis of actual costs and obtained from concluded agreements and contracts (in US$).
- Financial Flows are identified on the basis of data on the actual costs of personnel training for the operation of gas turbine power plants and upgrading the skills of power plant personnel;
- Operation and Maintenance costs (O&M) was derived for raw materials, fuel, labor and others from annual reports of power plants and converted into US$ at the official exchange rate.

From tables 7-8 it can be seen that the historical data reflect the investment growth as a result of implementing the above-mentioned measures for the new construction and modernization of generating capacities based on energy-saving technologies. This situation can be explained by the intention of the government of the Republic to improve the energy supply of the Republic's economy and increase its effectiveness. Over the entire historical period, the cost of construction and modernization of generating capacity (IF + FF + O&M) amounted to US$ 13.3 billion, including: US$ 3.3 billion for capital expenditures, US$ 0.449 billion for current expenses, US$ 9.6 billion for operating costs. At the same time, of the total amount of expenses, construction and modernization of thermal power plants accounted for 94%, and hydroelectric power stations accounted for 6%.

Table 6. Historical I&FF data for generating capacities (US$ million)

Year	Total flows (IF + FF + O&M)	including:		
		Investment Flows (IF)	Financial Flows (FF)	Operation and Maintenance Cost (O&M)
2010	1364.6	380.6	32.9	951.0
2011	1384.4	318.4	36.5	1029.5
2012	1513.5	406.5	45.4	1061.7
2013	1688.3	469.1	58.2	1161.0
2014	1844.2	576.9	47.0	1220.3
2015	1896.8	413.4	69.3	1414.1
2016	2134.9	585.5	77.9	1471.5
2017	1518.5	170.8	82.2	1265.5
Total	**13345.2**	**3321.3**	**449.2**	**9574.7**

Source: Joint-stock company "Uzbekenergo", joint-stock company "Uzbekhydroenergo"

Table 7. Historical I&FF data by types of generating capacity (US$ million)

Year	Thermal power plants				Hydroelectric power stations			
	Total flows (IF + FF + O&M)	Invest-ment Flows (IF)	Finan-cial Flows (FF)	Operation and Mainte-nance cost (O&M)	Total flows (IF + FF + O&M)	Invest-ment Flows (IF)	Finan-cial Flows (FF)	Operation and Mainte-nance cost (O&M)
2010	1298.8	368.6	32.4	897.8	65.7	12.0	0.5	53.2
2011	1322.7	308.4	36.1	978.1	61.8	10.0	0.4	51.4
2012	1379.3	323.1	44.0	1012.2	134.3	83.3	1.4	49.6
2013	1589.7	420.2	56.2	1113.3	98.5	48.8	2.0	47.7
2014	1748.5	528.1	46.0	1174.4	95.7	48.8	1.0	45.9
2015	1802.9	364.6	68.3	1370.0	93.9	48.8	1.0	44.1
2016	1992.3	488.0	75.0	1429.3	142.6	97.5	2.9	42.2
2017	1370.7	69.2	78.1	1223.5	147.7	101.7	4.1	42.0
Total	**12504.9**	**2870.3**	**436.1**	**9198.5**	**840.3**	**451.0**	**13.1**	**376.2**

Source: Joint-stock company "Uzbekenergo", joint-stock company "Uzbekhydroenergo"

4. Scenarios

The I&FF assessment of the electricity sector is based on the Government's[39] decisions on the implementation of investment projects for the expansion, modernization and construction of new generating capacities between 2017-2021 and expert assessment of sector development for the period until 2025, with two scenarios: a baseline scenario and a mitigation scenario including measures to mitigate climate change.

4.1. Development Factors and Trends

Assumptions were determined about the pace of economic development in the medium and long term, serving as a framework for the development of all scenarios. For example: The development of Uzbekistan's economy for the period until 2025 provides for sustainable economic growth in accordance with internationally accepted definitions and characteristics of this concept. Based on the analysis of development trends, ressources and opportunities were assessed; with an average annual GDP growth rate of 4.3%, GDP growth is projected to increase 1.5 times. Accordingly, the demand for electricity in the economy will increase by 4.9% on average per year and reach 82.3 billion kWh.

Addressing this task in Uzbekistan has already begun with the implementation of the Program of Measures to Ensure Structural Transformation, Modernization and Diversification of Production for 2015-2019,[40] aimed at creating conditions for the development of new modern industries focused on the production of goods in demand on the external and internal markets, allocating the production of raw materials and processed goods on the basis of crating national value chains of domestic raw materials.[41]

The main factors of economic growth will be the measures for the development of industries that produce processed goods with high added value based on in-depth processing of available mineral and raw materials: chemical and petrochemical industry, machine building, electro-technical industry,

[39] Decree of the President of the Republic of Uzbekistan of 04.03.2015 No. UP-4707. "Program of measures to ensure structural transformation, modernization and diversification of production for 2015-2019." Resolution of the President of the Republic of Uzbekistan of May 2, 2017 No. PP-2947 "On the program of measures for the further development of hydropower for the years 2017-2021". Resolution of the President of the Republic of Uzbekistan of May 26, 2017 No. PP-3012 "On the program of measures for the further development of renewable energy, improving energy efficiency in the economic and social sectors for 2017-2021". Resolution of the Cabinet of Ministers of the Republic of Uzbekistan of 14.09. 2017, №724 "On additional measures to expand the use of the country's hydropower potential through the implementation of pilot projects for the construction of micro hydroelectric power plants."

[40] Decree of the President of the Republic of Uzbekistan of 04.03.2015 No. UP-4707.

[41] Decree of the President of the Republic of Uzbekistan dated February 11, 2015 No. PP-2298 "On the program of localization of production of finished products, components and materials for 2015-2019".

production of building materials, as well as pharmaceutical, leather and footwear and food industries and other manufacturing industries.

In order to support economic growth in Uzbekistan, the main directions of the transition to a resource-saving growth model for the period until 2025 have been determined, as well as measures to reduce energy intensity, the introduction of energy-saving technologies in the sectors of the economy and the social sphere, and the development of renewable energy sources.[42]

However, it should be noted that global climate change is accompanied by an increase in air temperature and, as a consequence, a reduction in the country's hydropower potential. At the same time, various sources project:

- an increase in the average annual air temperature in the territory of Uzbekistan by 2025 on average by 1.5-2 °C relative to the base year;[43]
- a reduction of the annual flow of individual rivers in the Amudarya river basin by 7-22%, the Syr Darya river by 5-42%,[44] as well as of the runoff from local rivers (the Surkhandarya River – reduction by 30%, the Kashkadarya River - by 50%, the Sherabadarya River - by 20%, the Akhangaran River - by 10%, the Chirchik River - by 8%).[45]

As a result, hydroelectric power plants are expected to reduce electricity production compared to the base year due to a lack of necessary water resources. In this context, the change in the hydropower potential, as a result of the increase in air temperature, will directly affect the reduction of electricity generation and the efficiency of the distribution and transmission infrastructures of the electric power industry.

These forecasts were the basis for both scenarios.

4.2. Baseline Scenario

In this scenario an urgent need is assumed to increase the required capacity to produce electricity during 2017-2025 to support economic growth and to ensure the development of the energy sector together with a reduction of the carbon footprint. The scenario takes into account:

1. The implementation of large investment projects to expand, modernize and build new thermal generating capacities by removing obsolete and physically

[42] Resolution of the President of the Republic of Uzbekistan of May 26, 2017 No. PP-3012 "On the program of measures for the further development of renewable energy, improving energy efficiency in the economic and social sectors for 2017-2021".

[43] The Third National Communication of the Republic of Uzbekistan on the UN Framework Convention on Climate Change. Tashkent. UzGidromet. 2016.

[44] The Third National Communication of the Republic of Uzbekistan under the United Nations Framework Convention on Climate Change. Tashkent. 2016.

[45] Chen Shi, Makhmudov E.Zh. Water resources and water use in Uzbekistan. - Publishing house of LLC Pliograf Groop - Tashkent, 2013.

worn out equipment from Thermal Power Plants and Combined Heat and Power Plants and replacing them with new modern resource-saving facilities according to existing plans. For example, in accordance with the Program for the Development of Industry for 2015-2019,[46] in the medium term it is planned to build and modernize such capacities as:

- Construction of a second Combined-Cycle Plant with a capacity of 450 MW at Navoi Thermal Power Plant (commissioned in 2019);
- Construction of a new thermal power plant consisting of two 450 MW Combined-Cycle Plant units in the Syrdarya region (2018);
- Construction of a Combined-Cycle Plant at Fergana Thermal Power Plant with a capacity of 24 MW (2020-2021);
- Modernization and expansion of the Tashkent Combined Heat and Power Plant with the construction of the 2nd and 3rd Geothermal Unit with a capacity of 27 MW (54 MW) (2021);
- Expansion of the capacity of Takhiatash Thermal Power Plant with the construction of two Combined-Cycle Plants with a total capacity of 500 MW (2020);
- Expansion of the Talimarjan Thermal Power Plant with the construction of another two Combined-Cycle Plants with a capacity of 450 MW (900 MW) (2020-2021);
- Construction of the 3rd 450 MW Combined-Cycle Plant unit at Navoi Thermal Power Plant (2019-2021);
- Construction of a new combined thermal power plant consisting of two 450 MW Combined-Cycle Plant units in the Turakurgan district of the Namangan region (900 MW), (2019-2020).

2. Expansion of hydropower potential due to construction of 42 new and upgrading 32 operating hydroelectric power stations on natural watercourses and water management facilities of the Republic. In particular, according to the Program of Measures for the Further Development of Hydropower for 2017-2021,[47] the joint-stock company "Uzbekhydroenergo" foresees to:

- construct 18 new hydroelectric power plants with a total capacity of 984.7 MW with an investment volume of US$ 2,038.8 million, and to implement 24 projects for the construction of new hydroelectric power plants with a total capacity of 637.3 MW with an investment volume of US$ 1223.8 million;
- modernize 14 operating hydroelectric power plants with a total capacity of 1,400 MW and with an investment volume of US$ 609.8 million, as well as to implement 18 projects for the modernization of existing hydroelectric power stations with a capacity of 588 MW during 2018-2030. with an investment of US$ 469 million.

[46] Decree of the President of the Republic of Uzbekistan No. UP-4707 of March 4, 2015 "On the Program of Measures to Ensure Structural Transformation, Modernization and Diversification of Production for 2015-2019".

[47] Decree of the President of the Republic of Uzbekistan of 02.05.2017 N PP-2947 "On the Program of Measures for the Further Development of Hydropower for 2017-2021".

The implementation of the baseline scenario during 2017-2025 projects:

- to increase the power generation capacity of thermal power plants by 5,400 MW, which will ensure the growth of total capacity, taking into account their retirement from 12.4 thousand MW in 2016 to 15.4 thousand MW in 2025.
- to increase the capacity of the hydroelectric power plants of the Republic by 1.7 times, taking into account the forecasted increase in air temperature, and to bring them up from 1.7 thousand MW in 2016 to 3,000 MW in 2025. At the same time, their share in the total electricity generation will increase from 12.7% to 15.8%; and the total input capacity of the hydroelectric power plants will be 1.25 thousand MW, electricity generation will increase by 5 billion kWh;
- to reduce the specific fuel consumption for electricity generation from 375.8 g/kWh (2016) to 283.5 g/kWh. (2021), which is equivalent to an annual saving of natural gas in the amount of 4.78 billion m^3;
- to reduce greenhouse gas emissions in general for the period of 8.8 million tons CO_2-eq.

It is estimated that the implementation of the baseline scenario in 2017-2025 will require total I&FF of US$ 26.1 billion, Investment Flows of US$ 11.4 billion, Financial Flows of US$ 1.2 billion, the operation and maintenance costs in the system of thermal power plants and hydroelectric power plants will amount to US$ 13.4 billion (Tables 8-9).

Table 8. Projection of I&FF for generating capacities in the baseline scenario (US$ million)

Year	Total flows (IF + FF + O&M)	including: Investment Flows (IF)	Financial Flows (FF)	Operation and Maintenance cost (O&M)
2017	1518.5	170.8	82.2	1265.5
2018	2005.6	590.3	104.9	1310.5
2019	2330.0	854.1	112.4	1363.5
2020	2494.1	949.9	122.9	1421.3
2021	3857.4	2249.7	130.8	1476.9
2022	3197.9	1501.1	142.8	1554.0
2023	3220.9	1456.5	152.4	1612.0
2024	3622.1	1783.6	161.8	1676.7
2025	3820.5	1918.1	172.1	1730.3
Total:	**26067.1**	**11474.1**	**1182.4**	**13410.6**

Source: Joint-stock company "Uzbekenergo"

Table 9. Projection of I&FF by types of generating capacities in the baseline scenario (US$ million)

Year	Thermal power plants				Hydroelectric power stations			
	Total flows (IF + FF + O&M)	Invest-ment Flows (IF)	Finan-cial Flows (FF)	Operation and Mainte-nance cost (O&M)	Total flows (IF + FF + O&M)	Invest-ment Flows (IF)	Finan-cial Flows (FF)	Operation and Mainte-nance cost (O&M)
2017	1370.7	69.2	78.1	1223.5	147.7	101.7	4.1	42.0
2018	1755.5	383.9	96.6	1275.0	250.1	206.4	8.3	35.5
2019	2095.0	665.0	104.8	1325.2	235.0	189.1	7.6	38.3
2020	2263.9	768.4	115.6	1379.9	230.2	181.5	7.3	41.4
2021	3699.6	2141.0	126.4	1432.2	157.8	108.8	4.4	44.7
2022	3005.4	1362.4	137.2	1505.8	192.5	138.7	5.6	48.3
2023	3055.4	1347.5	148.0	1559.8	165.5	109.0	4.4	52.1
2024	3488.7	1709.5	158.8	1620.4	133.4	74.1	3.0	56.3
2025	3695.1	1856.0	169.6	1669.5	125.3	62.1	2.5	60.8
Total	**24429.4**	**10302.7**	**1135.3**	**12991.4**	**1637.6**	**1171.4**	**47.0**	**419.2**

Table 10. Projection of I&FF in the baseline scenario by source of financing (% of total)

Year	Total flows (IF + FF + O&M)	including:		
		Own means of enterprises	Public funds	Foreign funds
2017	100.0	53.7	25.1	21.2
2018	100.0	52.6	25.2	22.2
2019	100.0	52.3	25.2	22.5
2020	100.0	52.0	25.3	22.8
2021	100.0	51.7	25.3	23.0
2022	100.0	51.3	25.4	23.3
2023	100.0	51.0	25.4	23.6
2024	100.0	50.7	25.5	23.8
2025	100.0	50.4	25.5	24.1

Source: Joint-stock company "Uzbekenergo", joint-stock company "Uzbekhydroenergo", authors' calculations

4.3 Mitigation Scenario

The mitigation scenario, in addition to the conditions and measures of the baseline scenario, takes into account:

1. The implementation of the planned demonstration projects for the construction of new photovoltaic and wind power plants, which ensure high efficiency of power generation. Accounted in the mitigation scenario, the implementation of these projects is conditioned by:

- The vulnerability of Uzbekistan's energy system in terms of energy security, as it is based on electricity generation with a dominant use of natural gas (94%);
- The weak correlation of the current implementation pace of measures for modernization and technological re-equipment of the traditional electric power industry with the forecasts of economic development and population growth, as well as unresolved issues of guaranteed energy supply to remote and hard-to-reach regions of the country;
- The slow development in diversifying the structure of electricity generation sources from traditional fuels, and replacing them with renewable sources of energy (solar, wind etc.).

Consequently, the provision of significant resources and the development of renewable energy could become not only one of the tools for ensuring the country's energy security, but also contribute to the goals of the country's economic development, improve living conditions of the population and work in hard-to-reach areas, and diversify the fuel- energy balance of the country;

The expert working group on I&FF assessment proposes the implementation of the following projects during 2018-2025 (Table 10).

Table 11. Proposed measures for the construction of promising projects for renewable energy sources for 2018-2025 (US$ million)

№	Name of project	Project capacity, MW	Terms of implementation	Total I&FF of the project
	Total:	**466.0**	**2018-2025**	**770.2**
	Investment projects for solar energy (26 projects), including:	**212.0**	**2018-2025**	**331.2**
1	Construction of a solar photovoltaic station in Muinak rayon of the Republic of Karakalpakstan	5.0	2018-2019	7.5
2	Construction of a solar photovoltaic station in the Kungrad region of the Republic of Karakalpakstan	5.0	2018-2019	6.2
3	Construction of solar photovoltaic power station in Bostanlyksky district of Tashkent region	2.0	2018-2019	3.5
4	Construction of a solar photovoltaic station in the Denau district of the Surkhandarya region	2.0	2018-2019	4.0
5	Construction of solar photovoltaic station in Karakul district of Bukhara region	10.0	2019-2020	18.0
6	Construction of solar photovoltaic power station in Alat district of Bukhara region	10.0	2019-2020	18.0
7	Construction of a solar photovoltaic power plant in the Shurchik region of the Surkhandarya region	10.0	2019-2020	18.0
8	Construction of solar photovoltaic power station in Oltinsay district of Surkhandarya region	10.0	2020-2021	18.0

9	Construction of a solar photovoltaic power plant in the Tandy district of the Bukhara region	5.0	2020-2021	15.0
10	Construction of solar photovoltaic power plant in Zaminsky district of Djizak region	4.0	2021-2022	10.0
11	Construction of a solar photovoltaic power plant in the Khazarasp district of the Khorezm region	25.0	2021-2022	15.0
12	Construction of a solar photovoltaic station in the city of Samarkand	10.0	2021-2022	18.0
13	Construction of solar photovoltaic power station in Naryn district of Namagan region	10.0	2021-2022	18.0
14	Construction of a solar photovoltaic power plant in the Pap District of the Namagan region	5.0	2022-2023	18.0
15	Construction of a solar photovoltaic station in the Chartak district of the Namagan region	15.0	2022-2023	18.0
16	Construction of solar photovoltaic station in Khanabad district of Andijan region	12.0	2022-2023	18.0
17	Construction of a solar photovoltaic power plant in the Pakhtaabad district of the Andijan region	12.0	2023-2024	18.0
18	Construction of a solar photovoltaic station in the Iskaskan district of the Andijan region	12.0	2023-2024	18.0
19	Construction of solar photovoltaic station in Shahristan district of Andijan region	12.0	2024-2025	18.0
20	Construction of a solar photovoltaic station in the Baghdad district of the Fergana region	12.0	2024-2025	18.0
21	Construction of a solar photovoltaic station in the Kushtepa district of the Fergana region	12.0	2024-2025	18.0
22	Construction of a solar photovoltaic power plant in the Tashlak region of the Fergana region	12.0	2024-2025	18.0
	Investment projects for wind energy (4 projects), including:	**254.0**	**2022-2025**	**439.0**
23	Construction of a pilot wind power station in Nurata district of Navoi region	10.0	2021-2022	18.0
24	Construction of a wind farm in Navoi region	102.0	2022-2023	180.0
25	Construction of a wind farm in the Republic of Karakalpakstan	102.0	2023-2024	180.0
26	Construction of a wind farm in the Jizzakh region	40.0	2024-2025	61.0

Source: Authors' calculations

Following the implementation of the mitigation scenario in 2017-2025, it is expected:

1. To satisfy the forecasted needs of the economy in electricity as a result of increasing demand from enterprises and the population, as well as improving guaranteed energy supply to remote and hard-to-reach regions of the country;

2. To increase the share of solar and wind energy in the country's total power generation from 0.001% to 2.5%, which is equivalent to the release of natural

gas for the whole period of 1.32 billion m^3 and, accordingly, the reduction of emissions, compared to the baseline scenario, by 2.4 million tons of CO_2.

3. To implement the total I&FF taking into account the costs of the baseline scenario in the amount of US$ 26.9 billion, including Investment Flows of US$ 12.2 billion, Financial Flows of US$ 1.2 billion and Operation & Maintenance costs of US$ 13.5 billion. At the same time, the total I&FF of alternative types of electricity will be US$ 854.9 million (Tables 11-12).

Table 12 Projection of I&FF for generating capacities in the mitigation scenario (US$ million)

Year	Total flows (IF + FF + O&M)	including: Investment Flows (IF)	Financial Flows (FF)	Operation and Maintenance cost (O&M)
2016	2134.9	585.5	77.9	1471.5
2017	1518.5	170.8	82.2	1265.5
2018	2017.8	600.9	105.2	1311.8
2019	2372.5	891.7	112.8	1368.0
2020	2543.2	993.4	123.3	1426.5
2021	3920.3	2305.7	131.4	1483.2
2022	3371.7	1657.6	146.2	1567.9
2023	3466.9	1681.5	155.5	1630.0
2024	3814.3	1958.1	164.6	1691.6
2025	3895.9	1984.6	174.6	1736.7
Total:	**26921.1**	**12244.3**	**1195.7**	**13481.0**

Source: Authors' calculations

Table 13. Projection of I&FF by types of generating capacities in the mitigation scenario (US$ millions)

Year	Solar power engineering				Wind power engineering			
	Total flows (IF + FF + O&M)	Investment Flows (IF)	Financial Flows (FF)	Operation and Maintenance cost (O&M)	Total flows (IF + FF + O&M)	Investment Flows (IF)	Financial Flows (FF)	Operation and Maintenance cost (O&M)
2017								
2018	12.2	10.6	0.3	1.3				
2019	42.5	37.6	0.4	4.5				
2020	49.1	43.5	0.4	5.2	0.0			
2021	53.0	47.0	0.3	5.6	9.9	9.0	0.3	0.6
2022	64.7	57.5	0.3	6.9	109.0	99.0	3.1	6.9
2023	50.7	45.0	0.3	5.4	195.4	180.0	2.8	12.6
2024	60.7	54.0	0.3	6.5	131.4	120.5	2.5	8.4
2025	40.5	36.0	0.2	4.3	34.9	30.5	2.2	2.1
Total:	**373.4**	**331.2**	**2.5**	**39.7**	**480.6**	**439.0**	**10.8**	**30.7**

Source: Authors' calculations

Table 14. Projection of I&FF for generating capacities in the scenario of mitigation by sources of financing, in %

Year	Total flows (IF + FF + O&M)	Own means of enterprises	including: Public funds	Foreign funds
2016	100.0	54.4	25.0	20.6
2017	100.0	53.1	25.1	21.8
2018	100.0	52.1	25.2	22.7
2019	100.0	51.5	25.3	23.2
2020	100.0	50.2	25.7	24.1
2021	100.0	49.2	25.7	25.0
2022	100.0	48.8	25.9	25.3
2023	100.0	47.6	26.1	26.4
2024	100.0	46.6	26.2	27.1
2025	100.0	46.3	26.4	27.3

Source: Authors' calculations

5. Results

An analysis of the above scenarios shows that the implementation of the action plan in the "Electric Power" sector in the mitigation scenario will help limit the negative consequences of climate change in the country.

With the total value of the I&FF shown in the tables (Tables 11-16), taking into account possible investments from other sources, including the funds of foreign financial organizations, the sustainable operation of the electricity sector will:

- meet the country's electricity needs;
- reduce greenhouse gas emissions;
- diversify the structure of electricity production; and
- increase in the share of renewable energy sources.

Table 15. Difference in I&FF between mitigation scenario and baseline scenario (US$ million)

Year	Total flows (IF + FF + O&M)	including:		
		Investment Flows (IF)	Financial Flows (FF)	Operation and Maintenance cost (O&M)
2017	0.00	0.00	0.00	0.00
2018	12.20	10.60	0.33	1.27
2019	42.47	37.60	0.36	4.51
2020	49.11	43.50	0.39	5.22
2021	62.90	56.00	0.63	6.27
2022	173.71	156.50	3.38	13.83
2023	246.04	225.00	3.04	18.00
2024	192.15	174.50	2.74	14.92
2025	75.42	66.50	2.47	6.45
Total:	**854.00**	**770.20**	**13,30**	**70.5**

Source: Authors' calculations

This assessment of investment and financial flows (I&FF), the first ever conducted in the Republic of Uzbekistan in the electricity sector, showed that this sector is vulnerable to the climate change projected up to 2025. This, in turn, determined the need to develop a set of measures aimed at the implementation of energy-saving projects to generate electricity and contribute to mitigating the negative impact of climate change.

Table 16. Difference in I&FF between the mitigation scenario and the baseline scenario for the types of generating capacity (US$ million)

Year	Total flows (IF + FF + O&M)	Thermal power plants	Hydro power plants	Solar power engineering				Wind power engineering			
		Total flows (IF + FF + O&M)	Total flows (IF + FF + O&M)	Total flows (IF + FF + O&M)	Invest-ment Flows (IF)	Finan-cial Flows (FF)	Opera-tion and Mainte-nance cost (O&M)	Total flows (IF + FF + O&M)	Invest-ment Flows (IF)	Finan-cial Flows (FF)	Opera-tion and Mainte-nance cost (O&M)
2017	0.00	0.0	0.0								
2018	12.20	0.0	0.0	12.2	10.6	0.3	1.3		0.0		
2019	42.47	0.0	0.0	42.5	37.6	0.4	4.5		0.0		
2020	49.11	0.0	0.0	49.1	43.5	0.4	5.2	0.0	0.0	0.0	0.0
2021	62.90	0.0	0.0	53.0	47.0	0.3	5.6	9.9	9.0	0.3	0.6
2022	173.71	0.0	0.0	64.7	57.5	0.3	6.9	109.0	99.0	3.1	6.9
2023	246.04	0.0	0.0	50.7	45.0	0.3	5.4	195.4	180.0	2.8	12.6
2024	192.15	0.0	0.0	60.7	54.0	0.3	6.5	131.4	120.5	2.5	8.4
2025	75.42	0.0	0.0	40.5	36.0	0.2	4.3	34.9	30.5	2.2	2.1
Total	**854.00**	**0.0**	**0.0**	**373.4**	**331.2**	**2.5**	**39.7**	**480.6**	**439.0**	**10.8**	**30.7**

Source: Authors' calculations

National specialists of the sector have acquired considerable experience and skills in conducting economic and financial analysis in this sector. International experts from Europe, UNDP (Ms. Olbrisch and others) and other countries have repeatedly conducted seminars and trainings on various issues of financial and economic analysis in Uzbekistan and other countries of the world and, most importantly, handed over to the national experts of Uzbekistan the "Methodological Guide for Assessing Investment and Financial Flows" for addressing to climate change mitigation and adaptation.

We believe that the results of the work prepared by the experts of the electricity sector will provide significant assistance and will be used by the leaders and relevant specialists of the ministries, departments and institutions of Uzbekistan to address issues related to making decisions to mitigate the negative impact of climate change.

The results of this paper have shown that the implementation of mitigation measures will significantly reduce the adverse effects of climate change in the sector. Required I&FF for the mitigation scenario exceed the I&FF compared to the baseline scenario by US$ 854 million due to additional implementation of investments in the field of alternative energy.

In general, the implementation of a set of mitigation measures based on the optimal use of renewable energy will ensure:

- the formation of conditions for the sustainable provision of regions with energy through the introduction of renewable energy sources;
- the reduction of mono-dependence in the energy sector from natural gas, thereby ensuring the country's energy security;

- the creation of a qualitatively new field of energy in the country: an alternative to traditional energy based on hydrocarbons by using renewable energy sources and applying qualitative new technological solutions that promote the development of high-tech industries;
- the active social and economic development of remote areas through guaranteed energy supply to business entities and the social sector;
- raising the technical level of specialists in the regions of construction and operation of renewable energy sources;
- the substitution of hydrocarbons and the restriction of greenhouse gas emissions into the atmosphere.

6. Political Implications

At the policy level, as part of the implementation of the mitigation scenario, it is necessary:

- to improve legislation and regulatory framework in the field of renewable energy sources;
- to create an organizational management structure and to introduce modern technologies in the field of use of renewable energy sources;
- to implement financial mechanisms to encourage the introduction of renewable energy sources, creating favorable conditions for attracting investments, primarily foreign direct investment;
- to stimulate the market (business) of renewable energy technologies by the state through tax benefits, "green" tariffs and other financial measures;
- to support the implementation of investment projects for the use of renewable energy sources, as well as the production of technological equipment for renewable energy;
- to form a modern database on technologies for the use of renewable energy sources, including both global and national experience in the development of renewable energy sources;
- to create a market of equipment, works and services in the field of the use of renewable energy sources, to strategically allocate the production of equipment for power generation based on renewable energy sources;
- to conduct research and experimental design work with the preparation of a complete set of design and technology documentation in the field of renewable energy use, in relation to the georaphic and climatic conditions of Uzbekistan;
- to stimulate demand among the population through concessional loans for the purchase of energy-efficient housing, subsidies for the installation of energy-efficient equipment and introduction of the use of renewable energy sources.

For the successful implementation of specific areas to expand the use of renewable energy, it is necessary:

- to establish a procedure for the examination of project solutions for renewable energy installations and monitoring its compliance;
- to establish stimulating "green tariffs" for electricity produced from renewable energy sources and purchased by state energy supply organizations, differentiated depending on the type of renewable energy sources and the capacity of facilities for the use of renewable energy sources;
- to provide a guaranteed connection to the unified energy network of installations for the use of renewable energy sources and the compulsory acquisition by the operators of energy supply organizations of the proposed energy produced from renewable energy sources on the basis of "green tariffs".

- to provide research and development works in the creation of energy-efficient equipment for the use of solar, wind and other renewable energy sources;
- to improve normative methodological documentation, legal and organizational basis in the use of local and renewable energy sources;
- to develop standards for the use of local and renewable energy sources, which are harmonized with relevant international standards and regulatory norms.
- to provide initial and refresher trainings, as well as advanced training of personnel in the field of renewable energy, including issues of production, design, construction and operation.
- to conduct awareness raising work in the field of the advantages of renewable energy sources for the consumer and training the population in the field of using renewable energy sources.

7. Uncertainties and Methodological Limitations

As the basic uncertainties it is necessary to note:

- the lack of an officially approved concept for the development of renewable energy in Uzbekistan for the medium- and long-term, which would serve as a guide for conducting projections for mitigating the effects of climate change;
- a lack of some data on Financial Flows for renewable energy sources, which made it necessary to determine them based on the extrapolation of existing data along with expert assessments;
- significant shortcomings regarding the quality of climate change forecasts, accurate calculations of the dynamics of air temperature increase and changes in Uzbekistan's water potential in the long term.

Chapter II. ASSESSMENT OF INVESTMENT AND FINANCIAL FLOWS (I&FF) TO ADDRESS CLIMATE CHANGE IN THE AGRICULTURE SECTOR

Introduction

Agriculture is one of the sectors of the economy that are most sensitive to climate change. Without a clear plan for implementing agricultural policies to address climate change, agricultural production and the lives of the rural population are exposed to risks. In Uzbekistan, the risks associated with climate change are urgent and fundamental, since the lives of the majority of the rural population (approximately 50% of the population live in rural areas[48]) directly or indirectly depend on agriculture.

In Uzbekistan, the agricultural sector is not adequately adapted to the current climate conditions, especially regarding the rational use of land and water resources.

To effectively address the climate change related risks for Uzbekistan's agriculture, and to use opportunities effectively, a clear plan is needed for implementing agricultural policy measures to address climate change, developing the capacity of major agricultural institutions and implementing the necessary investments in infrastructure, service and modernization of the agricultural sector.

This involves consulting with key stakeholders, especially farmers and agricultural specialists in the field, and requires investments in human resources, material and technical resources.

When developing such a plan, first of all, it is necessary to assess the investment and financial flows required for the implementation of adaptation measures.

Investment and financial flows for implementing adaptation measures and mitigating the negative consequences of climate change in the agricultural sector will ensure an increase in the volume of food production, as well as the sustainability of agricultural production.

Current investment and financial flows in the agricultural sector are mainly directed to the construction of hydraulic structures and irrigation systems, the

[48] According to the State Statistics Committee of the Republic of Uzbekistan.

reconstruction of inter-farm and on-farm reservoirs, the introduction of intensive and resource-saving technologies, among others. However, financial resources for adapting the agricultural sector to climate change or raising the awareness of agricultural producers about the negative effects of climate change are not yet sufficiently allocated.

This work assesses the movement of investment and financial flows in the agricultural sector and projects future investment and financial flows required for the modernization of agricultural production, and finally identifies entry points for mitigating the effects of climate change.

1. Objectives

The main goal of this work is to assess and analyze investment and financial flows,[49] to identify priorities for adaptation activities of the agricultural sector in the context of climate change.

To achieve this goal, the following tasks have been accomplished in the course of the work:

- analysis of national efforts to address climate change in the agricultural sector;
- assessment of investment and financial flows in the historical period (2010-2016);
- promoting the integration of climate change considerations into national planning;
- conducting a comparative data analysis of the baseline scenario and adaptation scenario;
- evaluation of the requirements/incentivs for implementing adaptation measures.

1.1 Justification

1.1.1. Previous Analyses Utilized

In this assessment various materials were used, from international conferences, seminars and meetings, as well as the results of international and national projects. This includes especially the sources:

1. Adaptation to climate change: Examples from Uzbekistan and Kazakhstan, UNDP, Tashkent, 2012.

2. Reducing the vulnerability of Uzbekistan's agriculture to climate change. World Bank, 2013.

3. The impact of climate change on water resources in Central Asia (Synthesis report), Almaty, 2009.

[49] "Investment flows" (IF) are investments in physical assets aimed at improving the land reclamation state (construction and reconstruction of collector drainage networks), as well as modernizing agricultural production.
"Financial flows" (FF) are the programmatic costs associated with training farmers, the costs of conducting training seminars, disseminating knowledge, conducting research in the field of improving land use.
"Operating and Maintenance Costs" (O&M) are operating expenses, which include: salary with deductions, inventory, payment for production services, fuel, energy, payment for insurance services and other current costs.

4. The results of the "Second National Communication on the United Nations Framework Convention on Climate Change", where the vulnerability analysis of the most important sectors of the economy and ecosystems was carried out, and recommendations were made for implementing preparatory measures to adapt them to possible climate change.

5. "National Action Plan of the President of Uzbekistan for Environmental Protection".

6. United Nations Development Program in Uzbekistan Project "Improvement and development of a database of environmental indicators using GIS for environmental monitoring in Uzbekistan". Ecological review of Uzbekistan based on indicators, Tashkent, 2009.

7. The Third National Communication of the Republic of Uzbekistan on the United Nations Framework Convention on Climate Change, Tashkent, 2016.

8. Official documents and materials of the Ministry of Agriculture and Water Resources of the Republic of Uzbekistan.

The sector agriculture is considered a priority for conducting an assessment of investment and financial flows due to the fact that the planned agricultural policy for Uzbekistan provides entry points for adapting to climate change in the near future by:[50]

- bringing forward structural reforms and dynamic development of agricultural production, further strengthening the country's food security, expanding the production of environmentally friendly products, and significantly increasing the export potential of the agricultural sector;
- further optimizing the used acreage, aimed at reducing the acreage under cotton and grain crops, allocating potatoes, vegetables, fodder and oil crops on newly released lands, as well as new intensive orchards and vineyards;
- stimulating and creating favorable conditions for the development of farms, primarily multi-profile farms, which are engaged in the production of agricultural products, as well as processing, harvesting, storage, marketing, construction and services;
- implementing investment projects for the construction of new processing enterprises, as well as the reconstruction and modernization of existing processing enterprises, to supply them with the most modern high-tech equipment for deeper processing of agricultural products, the production of semi-finished products and finished food products, as well as packaging products;
- further expanding the infrastructure for storage, transportation and marketing of agricultural products, providing agrochemical, financial and other modern market services; further improving the reclamation state of

[50] Decree of the President of the Republic of Uzbekistan "On the strategy of actions for the further development of the Republic of Uzbekistan" on February 7, 2017, No.UP-4947.

irrigated lands, developing a network of reclamation and irrigation facilities, widely introduce intensive methods into agricultural production, primarily modern water and resource-saving agrotechnologies, using high-performance agricultural machinery;

- expanding research works on creation and introduction of new varieties of agricultural crops resistant to diseases and pests adapted to local soil-climatic and ecological conditions, and breeds of animals with high productivity;
- adopting systemic measures to mitigate the negative impact of global climate change and the drying up of the Aral Sea, which impacts agricultural development and the livelihoods of the population.

The fulfillment of these tasks largely depends on the current state of agricultural development and its projected future changes.

Consequently, the issues of agricultural sustainability and the need to meet the growing food needs of the population indicate that addressing the agricultural impact of climate change is of great social and economic importance. Therefore, all adaptation measures considered in this assessment are aimed at the sustainable development of the agriculture sector and the rational use and sustainable management of land and water resources. Given the expected climate change, the implementation of these measures will guarantee the provision of people with food products.

To this end, the following adaptation measures are proposed to mitigate the adverse effects of climate change in the agricultural sector (these measures are not envisaged in the Presidential Decree):

- First of all, it is necessary to raise awareness of agricultural producers about the negative consequences of climate change, including ensuring free access of farmers to information from hydrometeorological services, and developing a system for providing farmers with the necessary information and adaptation technologies through the development of extension services;
- Financing and investing, measures to improve the water infrastructure and encouraging farmers to introduce water-saving technologies, such as the exemption from a land tax in areas where such technology is introduced etc.;
- Financing targeted scientific and technical programs for cultivating new varieties of drought-resistant crops, as well as animals, by expanding scientific research into the creation and introduction of new crop varieties resistant to diseases and pests adapted to local soil -climate and environmental conditions, and breeds of animals with high productivity;
- Improving the insurance system in agriculture, for example through crop insurance. It is necessary to increase the number of risks that can be insurance, and to implement better crop insurance schemes, especially for dry periods and pest insurance;
- Improving the credit system for adaptation measures from farmers and

households;

- Introducing improved schemes for allocating agricultural crops based on soil-climatic features and the level of regional support;
- Implementing targeted programs to strengthen the material and technical base of farmers, and expanding leasing services, since a farmer with the necessary equipment is more resistant to the effects of climate change;
- Developing a mechanism for the wide application of advanced intensive agricultural technologies for the production of agricultural products, and the introduction of modern resource- and water-saving technologies;
- It is necessary to organize training programs and seminars to increase the knowledge level on adaptation measures of farmers and agricultural workers in the field of agriculture and land management, training them on the use of these technologies, and in all regions of the country to create demonstration fields where seminars or training programs will be held.

1.1.2. Institutional Arrangements and Collaborations

A number of intersectoral meetings were organized with the participation of the main Ministries, departments, organizations and scientific research institutes of the Republic of Uzbekistan, in which the heads of departments and leading researchers participated. Institutional issues and cooperation issues between various organizations were discussed at the beginning of this assessment. Representatives of the following organizations and institutions took part in the inter-sectoral meetings:

- Center for Economic Research under the Service for the Coordination of Social and Economic Policy of the Office of the President of the Republic of Uzbekistan;
- Ministry of Agriculture and Water Resources;
- State Committee of Geodesy, Land Cadastre and Cartography;
- State Forestry Committee;
- Committee for Hydrometeorology under the Cabinet of Ministers;
- State Committee for Environmental Protection and Nature;
- Uzbek Scientific and Production Center of Agriculture;
- Research Institute of Agricultural Economics.

The above-mentioned organizations are the main owners of the necessary information on the challenges of agriculture, especially on issues of rational use and sustainable land- and water resources management as well as all having archived information for the historical period. Also future programs are developed here, and information on this is available in these organizations.

At the same time, the Uzbek Scientific Research and Production Center for Agriculture, and the Research Institute of Agricultural Economics are the main developers of research projects in the agricultural sector, and have experience in the field of addressing challenges related to agriculture, in particular issues of

rational use and sustainable management of land and water resources. The main data and information of the agricultural sector was obtained from the Ministry of Agriculture and Water Resources of Uzbekistan, the Uzbek Scientific Production Center for Agriculture and the Research Institute of Agricultural Economics.

1.1.3. Basic Methodology and Key Terminology

1. Establishment of key assessment parameters. The assessment of investment and financial flows on adaptating to climate change is an important activity in developing effective and appropriate national measures to mitigate the negative effects of climate change.

This document uses the "Methodological Handbook on the Assessment of Investment and Financial Flows to Address Climate Change, Section VIII," I&FF Evaluation for Adaptation of the Agricultural Sector", developed by UNDP, 2009.[51]

The following official documents were used for the assessment:

- Strategy of actions on five priority directions of development of the Republic of Uzbekistan 2017-2021;
- "Strategy of social and economic development of the Republic of Uzbekistan for the period until 2025", where the main measures of the development of the economy sectors up to 2025 are presented;
- "National Action Plan for the Protection of the Environment and Nature of Uzbekistan for 2017-2021";
- "The Third National Communication on the United Nations Framework Convention on Climate Change", Tashkent, 2016;
- Statistical reports on the Republic of Uzbekistan, where socio-economic development data for 2007-2016 is presented;
- Reports of the Ministry of Agriculture and Water Resources of the Republic of Uzbekistan, Agency for the Restructuring of Agricultural Enterprises;
- Reports of the State Committee of Geodesy, Land Cadastre and Cartography;
- Reports of the Scientific Research Institute of Agricultural Economics.

2. Establishing the baseline scenario. This section provides a description of the agricultural sector, the analysis of the development of the baseline scenario takes into account the expected trends in the change of key factors that have a significant impact on the development of the sector. The baseline scenario was developed based on this data and the associated annual I&FF were determined.

[51] Methodological Handbook on Assessing Investment and Financial Flows to Address Climate Change, New York, 2009.

For the baseline scenario, a number of assumptions were made about the most likely change in these variable factors.

In the area of agriculture, a number of state programs are implemented that contribute to the sustainable development of the sector. However, due to various conditions, such as the current economic situation in the Republic, the state of the international food market, population growth, the development of free economic zones, these programs are often adjusted. When adjusting the program, priority measures are set, and usually, the condition for maintaining the average level of development of the agricultural sector is adopted.

Therefore, the methodical approach of the baseline scenario until 2025 is based on the average measures of the development of the agriculture sector. Thus, the scale and growth rate of investment flows, financial flows and operation & maintenance costs until 2025 is expected to develop in the same dynamics as in the historical period 2010-2016.

3. Establishing the adaptation scenario and determining required changes of I&FF. The adaptation scenario involves, during the assessment period, the implementation of new policies and measures to address climate change. At the same time, policy measures to address climate change in the agriculture sector are considered in the context of sustainable development of agricultural production through the rational use of land and water resources, and through the introduction of intensive technologies. In this scenario, the I&FF associated with implementing climate change measures have been identified. By looking at the changes among baseline scenario and adaptation scenario, the necessary changes in I&FF were determined.

4. Conducting policy assessment. This aspect of the methodology touches upon the incentives of key Ministries, departments and relevant organizations to implement the proposed measures and provide the required I&FF. The methodology provides for the organization of consultations with the participation of all key parties on setting up a number of normative acts or incentive measures needed as an instrument for influencing investment decision-making. When looking at the results of the assessment, it is important to consider a qualitative assessment of economic, social and environmental benefits for the agriculture sector.

2. Scope, Data Input and Scenarios

2.1. State of the Agriculture Sector

The agriculture sector accounts for about 1/5 of the share of the GDP (Figure 1 and 2) and for 30% of the employment in Uzbekistan. Agriculture is an important source of income for rural residents of the country.

This section describes the agriculture sector with an analysis of its state, prospects and consequences, as well as possible challenges associated with climate change in the agriculture sector.

Figure 1. Dynamics of changes regarding the share of agriculture in Uzbekistan's GDP for 2000-2016 (in %)

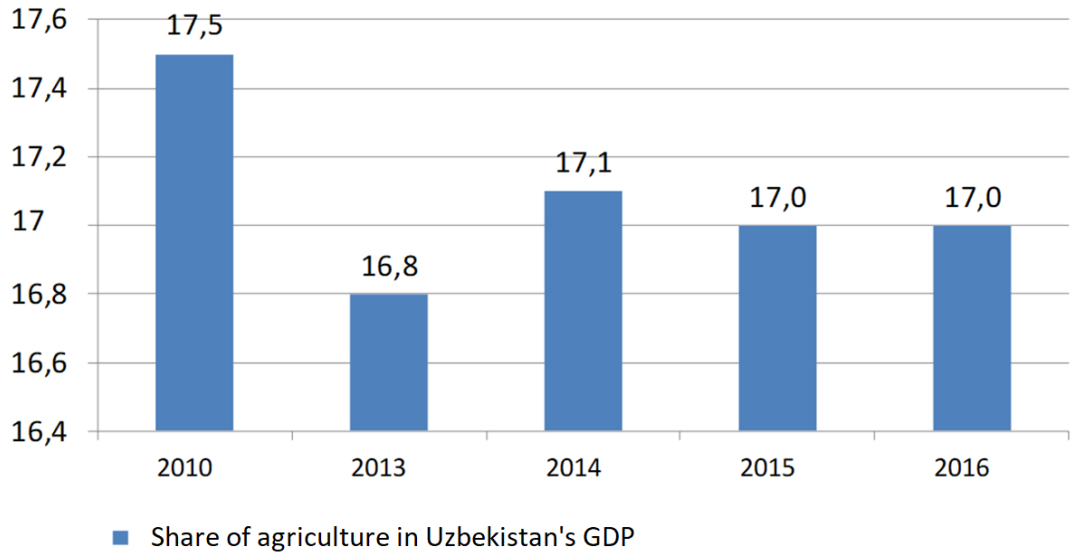
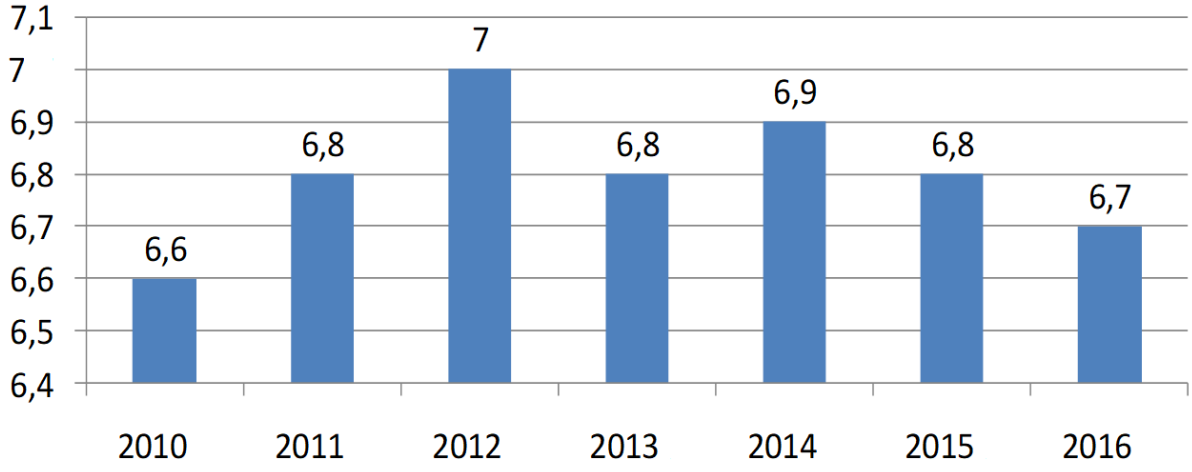


Figure 2. Major trends in agricultural production in Uzbekistan (in %)



Climatic conditions have a great impact on agriculture, and, therefore, most rural residents of Uzbekistan and their income sources are vulnerable to climate change. Data for previous years indicate that Uzbekistan has a very volatile climate, already expressed in an increase in average temperature, the number of extremely hot days and the evapotranspiration of plants (aridity). In general, climate forecasts indicate that Uzbekistan will be exposed to:

- an increase in the average annual temperature by 1.9-2.4°C by 2050, with a difference in the regions. The greatest warming is expected to occur in the winter and spring periods;
- 15-18% increase in the average annual rainfall by 2050 with the greatest increase in the summer season;
- gradual growth of the predicted water shortage in the Aral Sea basin as demand for water increases and the volume of available water withdrawal from the Amudarya and Syrdarya river basins decreases;
- a projected water deficit,which will increase from 2 km^3 in 2005 to 11-13 km^3 in 2050;
- riskier conditions of agricultural production, as the increase in temperature will lead to an increase in crop evaporation, offsetting the projected increase in precipitation and resulting in more arid agricultural production conditions, increasing the sector‘s dependence on already inadequate water resources;
- a high susceptibility to invasions of new agricultural pests and diseases of crops and livestock, caused by changes in temperature and precipitation conditions;
- an increase in the duration of the growing season, especially in the northern regions, giving opportunities for sowing new crops, increasing productivity and changes in crop structure.[52]

The predicted change in agroclimatic conditions poses a serious threat to agricultural production, the availability of water and economic growth, which contributes to increasing the incomes of rural residents. The degree of vulnerability of different areas of the country to climate risks and the associated opportunities for adaptation to climate change also differs significantly. The differentiation depends on a number of factors, including the local climate change impact, financial capacity, social structures, institutional capacity, knowledge and education, and access to infrastructure. Non-irrigated land with already low productivity will be even more threatened, while communities located in a relatively high rainfall or irrigated agriculture area have more options to adapt their agricultural production systems to predicted climate change, provided that there is sufficient water available for irrigation. In some cases there may also be potential for increased production due to climate change (for example, as a result of increasing the length of the growing season), which can be used if appropriate measures are taken.

The strong dependence of the agricultural sector on climate and water resources for irrigation needs has significant consequences for Uzbekistan. Given the

[52] U. Satton et al. (2013).

large proportion of poor rural populations relying on agriculture as their livelihood, rural communities are vulnerable to any changes that may occur as a result of climate change.

Relatively low productivity and potential gaps in adaptation to the existing climate conditions in Uzbekistan, also known as adaptation deficits, further increases the risks associated with climate change.

Inadequate yields of wheat and raw cotton in Uzbekistan may be associated with a set of factors, including deterioration and imperfect markets for processed agricultural products, material and technical resources; poor quality of services such as agricultural training, advanced training, research and marketing information systems; delays in farm restructuring and the underdeveloped agricultural land market; insufficient access to finance; deteriorating quality of land; poor seed quality; insufficient crop allocation systems; insufficient irrigation; as well as a strong vulnerability to risks associated with natural phenomena such as droughts and heat waves. The combination of these factors with the increasing challenges caused by climate change impacts underscore the importance of the measures that must now be taken to address the problem of adaptation deficiency in any climate change adaptation strategy for Uzbekistan.

To address the effects of climate change, it is necessary to develop a mechanism for implementing the following adaptation measures:[53]

- improved management of land, pasture, water and forest resources;
- use of economical methods of watering plants;
- introduction of drought-resistant crops and combating drought;
- the creation of greenhouses at farms that guarantee the protection of crops against frost and temperature fluctuations;
- implementation of energy saving and energy efficiency measures;
- preservation of local agro- and biological diversity, improvement of local environmental management etc.

2.2. Regulatory and Legal Fremework of the Sector Agriculture

The Land Code of the Republic of Uzbekistan. April 30, 1998. The Land Code consists of 14 chapters and 91 articles. The main objectives of the Land Code is to regulate land relations in order to ensure, in the interests of present and future generations, scientifically based, the rational use and protection of lands, instauration and improvement of soil fertility, preservation and improvement of the natural environment, creation of conditions for an equitable development of all forms of management, protection of rights legal entities and individuals to land plots, as well as strengthening the rule of law in this area.

[53] Proposed measures in accordance with the Resolution of the President of the Republic of Uzbekistan of 29.12.2015. No. PP-2460.

Law of the Republic of Uzbekistan "On farming", August 26, 2004. The Law "On Farming" defines the organizational and legal principles for farming establishment, rights and obligations, and their relationships with other legal entities and individuals. Until January 1, 2016, the provision of land for farming was carried out by the decision of the district Hokim. The Decree of the Cabinet of Ministers of the Republic of Uzbekistan of December 15, 2015, "On Measures to Optimize the Size of Land Plots Provided for the Management of Farms" No. 362 established a new procedure, according to which, starting 2016, the submission of land plots for farming and their removal is carried out on the basis of the decision of the district Kengashes by people's deputies on the conclusion of territorial councils of farmers and the commission, to review the issues of granting (selling) land plots.

The Law of the Republic of Uzbekistan "On Dehkan Farms", April 30, 1998. The Law "On Dehkan Farms" consists of 7 chapters and 31 articles and defines the legal basis for the creation, operation and liquidation of them, regulates their rights and obligations, regulates relations with other legal entities and individuals. Dehkan farming is carried out on agricultural land and forest lands not covered by forest plantations, as well as on reserve lands. Citizens who have a family and reside in the countryside for at least three years are granted a permanent plot of land for the maintenance of a dehkan farm in the amount of no more than 0.35 hectares for irrigated land and no more than 0.5 hectares for rain-fed (non-irrigated) lands, and in the steppe and desert zone there are no more than 1 hectare of irrigated pastures. For land masses newly under irrigation, the requirement to live in rural areas for at least three years is not applied. At the same time, the size of the land plot provided for dehkan farming is determined taking into account the previously or currently granted land plot for a lifetime of inheritable possession for individual housing construction.

Decree of the President of the Republic of Uzbekistan "On the most important directions of deepening the reforms of agriculture" of March 24, 2003 No.UP-3226. This decree was adopted with a view to further deepening economic reforms in agriculture, improving production relations in the countryside, introducing an organizational structure for managing agricultural production that conforms to market principles, as well as increasing the independence of producers of agricultural products and ensuring their reliable legal protection.

Decree of the President of the Republic of Uzbekistan "On the concept of the development of farms for 2004-2006" of October 27, 2003, No. UP-3342. This decree was adopted with a view to accelerating economic reforms in agriculture on the basis of priority development of farms, which in the future should become the main subject: the producer of agricultural products. In the context of climate change, the following main points of the concept are important: 1. The creation of a modern, widely accessible information system for farmers on the latest the achievements of agricultural science, technology and agrico-technology; 2. The implementation of a system of measures to stimulate and increase the responsibility of farmers for the targeted, rational and effective use

of land and water resources, increase soil fertility and land reclamation and others.

Resolution of the Cabinet of Ministers of the Republic of Uzbekistan "On improving the system for determining the normative value of agricultural lands" August 18, 2014, 235. The decree approved the "Regulations on the procedure for determining the normative value of agricultural land". The Regulation administers the procedure for determining the normative value of agricultural land of agricultural producers in the Republic of Uzbekistan. The Resolution consists of 6 sections and 8 paragraphs.

Decree of the Cabinet of Ministers of the Republic of Uzbekistan "On Measures to Optimize the Size of Land Plots Provided for the Management of Farms" of December 15, 2015 No. 362. This Decree was adopted with a view to further improving the efficiency of farming activities, as well as ensuring rational use of land and water resources, financial and economic condition of farms. Work was carried out to inventorize the size of land, based on the climatic, demographic and economic characteristics of the regions, as well as with the chronic shortage of irrigation water and in order to improve the adaptation of farmers to the negative effects of climate change. As a result, as of 01.12.2015, the total number of farms was 88,514 units and the avarage size of the land plot of farms was 43.9 hectares, against 101,070 units and 36.1 hectares on 01.10.2015. As a result, it became possible to efficiently and rationally manage land resources in farms.

2.3. Assessment of the State of Land-Use in Agriculture

The Republic of Uzbekistan is a country with an arid climate with a total area of about 44.5 million hectares, consisting mainly of mountains (20%) and arid/semi-arid areas (70%); the rest of the country is intensively irrigated valleys, located along the 2 large rivers of the country (Syr Darya and Amudarya). The largest desert of Central Asia, Kyzylkum, covers most of the lowlands and plains in the west and south of the country.

The three largest categories of land in Uzbekistan (Table 1) are: agricultural land (46.1%); forest land (21.7%), as well as reserve lands (27.6%). In total, these categories of land cover more than 42 million hectares (95% of the country's territory). Of this area arable land (including personal subsidiary plots) is only about 11%.

Table 1. Land categories of Uzbekistan and area occupied (as of 2015)

Land categories	Area, thousand hectares	%
Agricultural purpose	20481.1	46.10
Forest land	9636.9	21.70
Inventory	12250.2	27.60
Industrial, transport, communications, defense and other purposes	914.5	2.10
Water fund	831.4	1.90
Human settlements	214.1	0.50
Environmental, recreational and recreational purposes	75.9	0.20
Historical and cultural purpose	6.2	0.01
Total land resources of Uzbekistan	**44410.3**	**100.00**

As can be seen from Table 2 below, within these three categories of land, there are pasture or forest land. Thus, in aggregate, at least 20.7 million hectares are grazing lands (approximately 46.5% of the total area of land designated for agriculture, forestry or stock), and in practice, an even larger area is used in this way. Due to the arid climate, agricultural production is almost completely dependent on irrigation, and only about 751.5 thousand hectares (18.5%) of arable land are rainfed.

Table 2. Specification of agricultural land (as of 2015)

Type of land-use	Area, thousand hectares	in% of the category
Arable land (irrigated 82%, rain-fed 18%.)	4043.4	19.7
Perennial plantations (fruit, vineyards, mulberry trees, etc.)	344.6	1.7
Household plots	616.2	3.0
Hayfields and pastures	11134.5	54.4
Forest plantations (forest belts, poplar plantations)	209.9	1.0
Shrubs	31.3	0.2
Lands in the meliorative construction phase	70.5	0.3
Deposit land	78.4	0.4
Unused land	3952.3	19.3
Total (46.1% of the country's area)	**20481.1**	**100.0**

According to the aridity index of UNEP, most of the territory of Uzbekistan, with the exception of foothills and mountains, is classified as an arid zone and is therefore highly prone to land degradation and desertification. Foothills and mountains, although less prone to drought, are more prone to erosion and natural disasters, including landslides and mudflows. This trend, according to preliminary forecasts, will increase in the future as a result of projected climate changes (increase in aridity of lowlands, increased intensity of precipitation in the middle reaches and a decrease in the accumulation of snow and ice in the highlands).

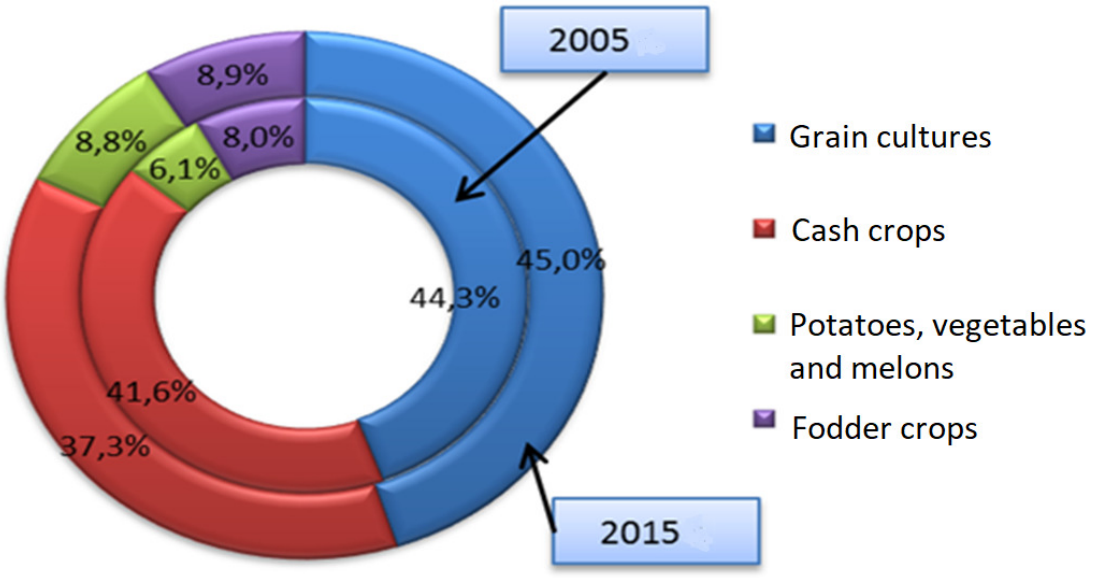
The most serious environmental problems threatening the country's natural resources include increasing soil salinization and water pollution, wind and water erosion, excessive grazing, deforestation and reduction of biodiversity, and a decrease in the productivity of arable land. Over the past 15-20 years, there has also been extensive degradation of pastures due to excessive grazing, lack of proper pasture care and other anthropogenic factors. The productivity of land is falling, and the scale of wind and water erosion is increasing.

Structural reforms carried out in the agricultural sector of Uzbekistan imply a change in the structure of cultivated areas due to optimization of crops for cotton and an increase in areas for grain crops, vegetable growing, horticulture and viticulture. As a result of works to further diversify the agricultural production of the Republic of Uzbekistan over the past 10 years, there have been significant changes in the structure of crop areas (Figure 3).

As a result of the ongoing targeted policy of gradual release of acreage under cotton and the introduction of cereals, vegetables, melons, potatoes and fodder crops on these lands, for the period 2005-2015, the area under cotton decreased by 171.2 thousand hectares, the share of cash crops crops was reduced to 37.3%.

Due to the released land and the increase in acreage (by 30,400 ha), the area under other crops has increased. In particular, the area of grain crops increased by 39.3 thousand hectares, vegetables by 54.2 thousand hectares, potatoes by 30.5 thousand hectares, melons by 17.6 thousand hectares, fodder crops by 35,8 thousand hectares.

Figure 3. Structure of acreage in 2005-2015 (in %)



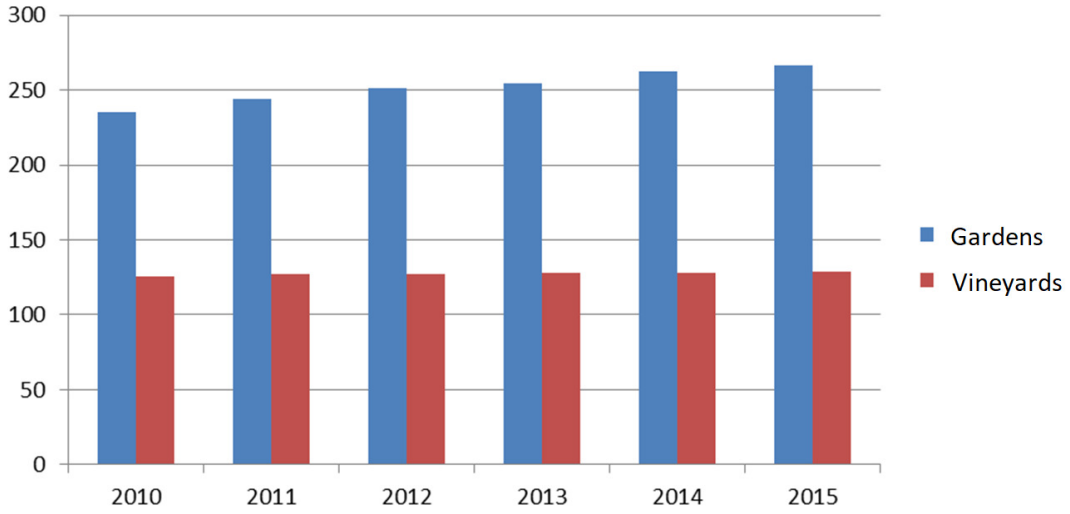
Source: State Committee of the Republic of Uzbekistan on Statistics.

There is a tendency to increase the area of gardens, primarily due to the creation of new high-performance intensive dwarf plantations. The total area of gardens

in 2015 amounted to 266.5 thousand hectares, which is 32 thousand hectares or 13.0% more than in 2010 (Figure 4).

The analysis of statistical data shows that the increase in the area under the gardens was primarily due to the planting of new plantations with highly effective intensive dwarf species (Table 3).

Figure 4. Dynamics of the area of perennial plantations in 2010-2015 (in thousand hectares)



Source: Data from the State Statistics Committee of Uzbekistan.

Table 3. Information about the created intensive gardens in Uzbekistan for 2011-2016

№	Regions	Total created intensive gardens for the period 2011-2016	including					
			2011	2012	2013	2014	2015	2016
1	Republic of Karakalpakstan	469				37	187	245
	field of							
2	Andijan	3365	156	121	441	580	1100	968
3	Bukhara	916	30	101	281	82	176	247
4	Jizzakh	2837	118	196	102	324	1249	848
5	Kashkadarya	2452	225	316	365	437	611	498,3
6	Navoi	1483	124	649	202	211	65	232
7	Namangan	4063	236	171	352	1122	1309	873,1
8	Samarkand	5599	639	636	484	1148	1968	724
9	Surkhandarya	2590	215	158	155	355	408	1299
10	Sirdarya	452	20	44	43		97	248
11	Tashkent	5663	644	318	514	1061	1833	1293
12	Fergana	1590	44	39	300	151	514	543
13	Khorezm	557		27	33	50	299	149
Total		**32037**	**2451**	**2775**	**3270**	**5558**	**9816**	**8167**

Based on the program of further improving the organization and development of viticulture in 2013-2015,[54] measures were implemented to increase the area of vineyards, which increased from 120.7 thousand hectares to 129.0 thousand hectares (by 8.3%).

The increasing acreage for new plantations of vineyards and orchards is due to a reduction of sowing grain crops on lands with a low level of water availability, in particular, the sowing lands of some districts of such regions as Djizak, Samarkand and Tashkent.

All these measures are a continuation of the purposeful policy of optimizing the sowing lands used in agricultural crop rotation, on the one hand. On the other hand, this is the result of the policy of providing the population with food products of own production, since this sub-sector is the basis for the development of the domestic food industry.

The main results of agricultural development during the analyzed period are qualitative changes in the structure and diversification of agricultural production, the development of farms, the creation of mechanisms for selling livestock to the population and farms at auction, the allocation of preferential targeted loans, the expansion and the improvement of the quality of veterinary services, as well as the provision of feed.

Despite the favorable trends in the development of agriculture in recent years, there are still a number of problems hampering its further growth, which include the following:

- sown land for wheat (38.7%) and cotton (36.1%) occupy about 74.8% of the total cultivated area, but at the same time there remains the problem of introducing scientifically justified crop rotations necessary to achieve high yields: out of the irrigated lands, about 49% are salinized to varying degrees, with about 18% being strongly and medium saline lands, over 23% being classified as low quality lands (by 2015);
- there is a low level of soft loans provided on agro-technology for the production of raw cotton and cereals for government needs (60%), which does not allow them to be processed in a timely and high-quality manner;
- the production of feed for intensive livestock keeping is inadequate due to a low share of fodder crops in the total cultivated area (8.6%). As a consequence, the volume of production of livestock is not sufficient to meet the needs of the population in accordance with rational consumption norms;
- the volume of investments related to agriculture is not sufficient, its share of the total volume of investments is only about 6.4%.

[54] Decree of the President of the Republic of Uzbekistan on March 13, 2010 No. PT-1937 "Omerakhdokalnevshemu development of wine growing in the Republic during the period 2013-2015".

According to the results obtained, the problem of limited land resources and the reduction of soil fertility will hamper the further increase in the production of agricultural products and the growing satisfaction of the needs of the growing population with food in the long term.

There is a trend to reduce the area of irrigated land and crop area per capita. At the same time, wheat (39.5%) and cotton (35.4%), which together account for almost ¾ of the total sown area, still prevail in the structure of the sown areas.

Currently, per person there are 0.161 hectares of irrigated land and 0.122 hectares of cultivated land. In the period until 2030, this trend is expected to increase. The risk of aggravation of problems of soil salinity and fertility deterioration is alarming: 18.4% (669.8 thousand hectares) of the total irrigated land area are classified as low quality and below average.

3. Data Input

3.1. Assessment Period and Cost Accounting Parameters

The assessment of I&FF for the sector was carried out for a time horizon of 2010 to 2025. The base year is 2016. The scenarios project 10 years into the future, starting from the base year 2016.

The data for I&FF assessment characterize the state and prospects of the sector development, the direction of investment in the construction and reconstruction of irrigation facilities, the repair and restoration of irrigation facilities at the expense of operational costs, the introduction of soil-protective and resource-saving technologies, as well as the purchase of equipment, current and operating costs.

To close some data gaps of investment and financial flows for 2010-2016 and to project values for 2017-2025, methods of expert assessments and data extrapolation were used.

3.2. Analytical Approach

When assessing the agriculture sector, the I&FF data in the national currency were used from the Ministry of Agriculture and Water Resources of the Republic of Uzbekistan, as well as data on agriculture projects implemented financed by International Financing Institutions.

The methodological approach in the baseline scenario is based on the rate of growth of I&FF for the period from 2010 to 2016, and based on them, the extrapolation method was used to calculate up to 2025. A particular feature of the I&FF analysis relationship in the agricultural sector is that investments are made from the state budget and the funds of the Microfinance Institutions. The scenario takes into account that the current situation and trends will continue.

Based on this, an adaptation scenario was calculated, based on a methodical approach on the implementation of specific measures that would reduce the negative impact of climate change on the agricultural sector by 2025. This served as the basis for determining the required investment and financial flows for their implementation.

When assessing I&FF, key documents were used such as: the Strategy of actions for the five priority development directions of the Republic of Uzbekistan in 2017-2021; and the "Program for the development of agriculture in Uzbekistan for the period until 2025". These documents were used by experts to determine a list of adaptation activities in the agriculture sector, taking into account climate change and the scarcity of water resources.

3.3. Historical IF, FF and O&M Data

Historical data on I&FF were collected and processed for 2010-2016 from materials including mapping research carried out during the historical period, conducted seminars, literature in the field of power systems development and I&FF estimates for the construction and modernization of generating capacities, as well as expert evaluations. Historical data on investment flows (2010-2016) were given by the Ministry of Agriculture and Water Resources.

Historical data on financial flows are received:

- from materials on the mapping of scientific research (grants) conducted during the historical period;
- based on the costs information from new research methods in the field of agriculture;
- from conferences on investment in agriculture;
- from projects relating to agriculture implemented by Microfinance Institutions;
- from expert assessments.

Over recent years, a number of state programs have been implemented in the agricultural sector of the Republic, the goal of which is to create the necessary conditions for the further sustainable development of agricultural production, increase the fertility of lands and, on this basis, increase crop yields.

In particular, the Decree of the President of the Republic of Uzbekistan No. PP-817 dated March 19, 2008 "On the State Program for Reclamation of Irrigated Lands for the period 2008-2012" approved the target parameters of the State Program for Land Improvement of Irrigated Lands for the period 2008-2012, implemented at the expense of the Fund for Reclamation of Irrigated Lands. Another Decree of the President of the Republic of Uzbekistan No. PP-1958 dated April 19, 2013 approved the "State Program on Rational Use of Water Resources and Improvement of the Reclamation Status of Irrigated Lands for the Period 2013-2017." In accordance with the Decree of the President of the Republic of Uzbekistan "On Measures for the Root Improvement of the Land Reclamation Improvement System" No.UP-3932 dated October 20, 2007, an effective mechanism was launched to organize integrated measures to improve the reclamation state of irrigated lands. In accordance with this Decree, the Irrigated Lands Reclamation Fund and the management structure have been established, as well as the Department for its management.

Within the framework of the implementation of the Comprehensive Measures on Ameliorative Improvement of Irrigated Lands and Rational Use of Water Resources, over 8.8 trillion soum from domestic sources and about US$ 2 billion from loans from international financial institutions were attracted and used only in 2012-2016.

Table 4. Historical I&FF data to improve irrigated lands and rational use of water resources, at the expense of public funds (million soum)

Activities	2012	2013	2014	2015	2016
State budget funds IF	**364 647.1**	**467 365.8**	**569 745.4**	**585 382.7**	**607 021.5**
Construction and reconstruction of irrigation facilities	318 677.0	409 687.0	503 799.0	512 467.0	525 961.0
Repair and restoration of irrigation facilities at the expense of maintenance costs	45 970.0	57 679.0	65 946.0	72 916.0	81 060.0
Funds of the Fund for Reclamation of Irrigated Lands	**210 000.0**	**227 500.0**	**252 091.1**	**263 103.3**	**272 775.2**
Construction and reconstruction of meliorative objects	91 710.0	95 000.0	102 990.0	107 100.0	109 600.0
Repair and restoration of meliorative objects	92 940.0	95 000.0	107 671.5	115 029.0	123 589.1
Purchase of land reclamation equipment	23 850.0	26 125.0	27 636.1	26 127.3	24 151.1
Reserve for the implementation of drip irrigation projects		9 375.0	11 793.5	12 847.0	13 435.0
Other work	1 500.0	2 000.0	2 000.0	2 000.0	2 000.0
Own means of farms and enterprises	**58 114.4**	**77 030.9**	**78 156.1**	**82 774.8**	**87 619.6**
Repair and restoration of irrigation facilities of farms	53921.0	60 737.9	65 367.6	69 801.1	74 742.6
Purchase of land reclamation equipment	4193.0	6 453.0	4 877.0	4 610.7	4 262.0
Introduction of drip irrigation and other advanced irrigation technologies		9 840.0	7 911.5	8 363.0	8 615.0
Total for the Program of Measures	**632 761.5**	**771 896.7**	**899 992.5**	**931 260.8**	**967 416.2**
Irrigation-reclamation measures implemented with the participation of Microfinance Institution loans (US$ million)	**97.9**	**114.1**	**194.9**	**245.4**	**256.7**

Source. Ministry of Economy of the Republic of Uzbekistan

The analysis of historical data on I&FF shows an improvement at reclamation of irrigated lands and a rational use of water resources at the expense of public funds for 2012-2016. In recent years of the "historical" period, there has been a decline in investment. During the period under review, the total investment amounted to US$ 1,675.2 million (IF + FF + O&M), of which the total cost amounted to US$ 1108.95 million or 66.2% of total costs for construction and reconstruction of irrigation facilities. For the repair and restoration of irrigation facilities, O&M costs were required of US$ 472.85 million or 28.2%, the purchase of equipment amounted to US$ 62.1 million or 3.7%, the introduction of soil-protective and resource-saving technologies (including drip irrigation) required US$ 31.3 million, or 1.9%, respectively (Tables 4 and 5).

Table 5. Historical I&FF data for improvement of irrigated lands and rational use of water resources from public resources (US$ million)

	Construction and reconstruction of irrigation facilities			Repair and restoration of irrigation facilities			Acquisition of equipment			Introduction of soil-protective and resource-saving technology (drip irrigation)		
	IF	FF	O&M	IF	FF	O&M	IF	FF	O&M	IF	FF	O&M
2012	206.8	0.0	0.60	97.2	0.0	0.20	14.1	0.0	0.0	0.0	0.0	0.0
2013	229.2	0.0	0.65	96.9	0.0	0.25	14.8	0.0	0.0	8.7	0.0	0.0
2014	250.9	0.0	0.60	98.8	0.0	0.20	13.4	0.0	0.0	8.1	0.0	0.0
2015	221.7	0.0	0.50	92.2	0.0	0.20	11.0	0.0	0.0	7.6	0.0	0.0
2016	197.5	0.0	0.50	86.8	0.0	0.10	8.8	0.0	0.0	6.9	0.0	0.0
Total	**1106.1**	**0.0**	**2.85**	**471.9**	**0.0**	**0.95**	**62.1**	**0.0**	**0.0**	**31.3**	**0.0**	**0.0**

Exchange rate US$/soum (at the end of each year): 2012 (1984.0 soum); 2013 (2202.2 soum); 2014 (2418.2 soum); 2015 (2795.0 soum); 2016 (3217.6 soum).

Table 6. Historical I&FF data for improving irrigated lands and the rational use of water resources from public resources (US$ million)

	Construction and reconstruction of irrigation facilities	Repair and restoration of irrigation facilities	Acquisition of equipment	Introduction of soil-protective and resource-saving technology (drip irrigation)
	IF+FF+O&M	IF+FF+O&M	IF+FF+O&M	IF+FF+O&M
2012	207.40	97.40	14.10	0.00
2013	229.85	97.15	14.80	8.70
2014	251.50	99.00	13.40	8.10
2015	222.20	924.00	11.00	7.60
2016	198.00	86.90	8.80	6.90
Total	**1108.95**	**472.85**	**62.10**	**31.30**

According to the Ministry of Agriculture and Water Resources for 2004-2017, International Financial Institutions have allocated and continue to allocate their investments in the agricultural sector. Such investors are the World Bank, the Asian Development Bank, the International Development Bank, the United Nations Development Programme (UNDP), Global Environment Facility (GEF), the International Fund for Agricultural Development and the Adaptation Fund (Table 6).

The table shows that the World Bank is investing US$ **53.4** million, the Asian Development Bank US$ **223.45** million, the World Bank with the international development organization US$ **68.0** million, the International Fund for Agricultural Development US$ **31.7** million, UNDP with the GEF US$ **13.3** million, and the Adaptation Fund US$ **5.0** million.

Based on the data it was calculated that the total amount of the investment is US$ 534 million of which US$ 443.6 million, or 83.1% accounted for by international financial institutions, the rest or US$ 90.4 million (16.9%) comesfrom the Government of Uzbekistan and local beneficiaries.

Table 7. Foreign investment in the agricultural sector (US$ million)

Project name	International Donors	Realization period	Total I&FF, US$ million	Donors' funds	Means of the Government of Uzbekistan and local beneficiaries
Draft drainage from South Karakalpakstan	World Bank	2004-2013	74.55	53.40	21.20
Improvement of land reclamation in Bukhara, Navoi and Kashkadarya regions	Asian Development Bank	2006–2015	76.20	60.20	16.00
Sustainable Land Management in Central Asia. 'International Center for Agricultural Research in the Dry Areas' Research Project	Asian Development Bank	Phase I -2007-2008 Phase II - 2013-2015	30.00	30.00	
Stabilizing ecosystems in degraded lands in Karakalpakstan and the Kyzylkum Desert	United Nations Development Programme, Global Environment Facility	2008-2012	2.90	1.10	1.80
Agricultural Enterprise Support Project, Phase II	World Bank, International Development Bank	2008-2016	121.00	68.00	53.00
Supporting the development of the fruit and vegetable sector in the Republic of Uzbekistan"	International Fund for Agricultural Development	2013-2016	31.70	31.70	
Ensuring sustainable development of agriculture and mitigating the effects of climate change"	Global Environment Facility	2013-2018	12.70	12.70	
Reducing the load on natural resources due to competing land use on non-irrigated arid mountain, semi-desert and desert landscapes of the Republic of Uzbekistan	United Nations Development Programme, Global Environment Facility	2014-2019	12.20	12.20	
Ensuring the climate resilience of farming and dehkan farms located in arid regions of Uzbekistan	Adaptation Fund	2014-2020	5.20	5.00	0.20
Development of the fruit and vegetable sector	World Bank	2015-2021	170.45	170.45	
Total			**534.00**	**443.60** (81,3%)	**90.41** (16,9%)

4. Scenarios

The I&FF assessment of the agriculture sector is developed on the basis of the Government's decisions on implementation of the agricultural diversification and modernization programs foreseen for 2016-2020 and expert assessment of sector development measures for the period up to 2025, with two scenarios: a baseline scenario and an adaptation scenario.

4.1. Development Factors and Trends

The identification of trends on the pace of economic development in the medium and long term served as a framework for the development of all scenarios. For example: The development of the economy of Uzbekistan for the period until 2025 was sustainabley growing in accordance with internationally accepted definitions and characteristics. Based on the analysis of development trends, estimates of resources and opportunities, with an average annual GDP growth rate of 4.3%, its volume is projected to increase 1.5 times within the projected time.

Undoubtedly, in the context of limited land and water resources and taking into account the constant growth of the population of the Republic, traditional methods of farming do not always provide coverage of the population's demand for food. Therefore, new approaches and mechanisms are required, a change in the structure of agricultural production as a whole, and the introduction of innovative and resource-saving technologies.

However, it should be noted that the global climate change is accompanied by an increase in air temperature and, as a consequence, a reduction in the country's hydropower potential. At the same time, according to various sources, it is projected that there will be:

- an increase in the average annual air temperature in the territory of Uzbekistan by 2025 at an average of 1.5-2°C relative to the base rate;[55]
- a reduction of the annual flow of individual rivers in the Amudarya river basin by 7-22%, in the Syr Darya river by 5-42%,[56] as well as in the runoff of the local rivers (the Surkhandarya River: reduction by 30%, the Kashkadarya River: by 50%, the Sherabadarya River: by 20% %, river Akhangaran: by 10%, the river Chirchik: by 8%).[57]

[55] The Third National Communication of the Republic of Uzbekistan on the UN Framework Convention on Climate Change. Tashkent. UzGidromet. 2016.

[56] The Third National Communication of the Republic of Uzbekistan under the United Nations Framework Convention on Climate Change. Tashkent. 2016.

[57] Chen Shi, Makhmudov E.Zh. Water resources and water use in Uzbekistan. - Publishing house of LLC Pliograf Groop. Tashkent, 2013.

Already at present the Republic is experiencing a significant water shortage, and with the current situation in irrigated agriculture, the predicted climate change will further exacerbate the existing water shortage in Uzbekistan.

Considering that 80% of the water resources consumed by Uzbekistan are come from the territory of neighboring countries, the issues of the impact of climate change on water resources Uzbekistan has always been considered in the context of this problem for the entire Central Asian region.

According to the estimates, the total water deficit in Uzbekistan in 2005 was $2km^3$, by 2030 it can increase to $7km^3$, and by 2050 to up to 11-$13km^3$.

There is a degradation of arable land (intensive salinization, all types of soil erosion), as a result of deficit of irrigation water and irrational nature management.

Due to the depletion of available water resources in the country, there has been a stabilization of irrigated land areas, which per capita are constantly decreasing.

The responses to climate change in of Uzbekistan's water sector are being considered in the context of two main strategies: A **restrictive strategy** to prevent and reduce the impact of climate change on water resources; and direct **adapting strategies** to the effects of climate change, which requires taking into account both negative and positive effects of climate change.

With regard to the **restrictive strategy**, the measures to prevent and reduce climate change in the water sector of the Republic include the following:

- Reducing CO_2 emissions to the atmosphere due to reducing energy consumption in the water sector as a result of the decommissioning pumping stations and the transition from machine irrigation to gravity irrigation;
- Reducing water loss due to increasing the efficiency of canals, modernization of hydraulic structures, and introduction of water-saving technologies.

In general, the **adaptation strategy** to the consequences of climate change in Uzbekistan is related to the optimization of water use and management, and is aimed at mitigating the water deficit and should include the following priority measures:[58]

- Introducing an integrated water resources management system by involving all stakeholders and linking it with land management;
- Introducing water-saving technologies on a broad level in water-consuming industries, agriculture and the public utilities sector in order to improve the efficiency of water use;

[58] Proposed measures in accordance with the Resolution of the President of the Republic of Uzbekistan of 29.12.2015. No. PP-2460.

- Reconstructing and maintening irrigation and drainage infrastructure in order to improve the efficiency of water use systems;
- Optimizing land use and selection of crops by aligning crops and irrigation regimes with suitable soil types for their cultivation, and introducing drought-resistant high-yield varieties;
- Implementing water resources control systems in all sectors of the economy;
- Strengthening institutional development in water use and water consumption;
- Supporting a number of agricultural reforms and strengthening the role of farm associations;
- Developing legal mechanisms for regulating water and land relations;
- Developing water resources monitoring, including the improvement of the water metering system and water quality management;
- Increasing knowledge and skills in sustainable water management;
- Building awareness of the population and fostering respect for water resources.

In summary it can be noted that all measures aimed at reducing water consumption and water loss, improving the technical state of hydraulic structures and reclamation state of irrigated lands, to some extent facilitate the adaptation to climate change, and also serve reducing climate changes.

4.2. Baseline Scenario

In the context of the aggravation of environmental problems, as well as the limited land and water resources availability, the structural agriculture policy of the Republic should continue accelerating modernization and technological renewal, introduce modern methods of agriculture, intensify the processing of agricultural raw materials, and radically improve the quality of life in rural areas of the population.

In this scenario, new approaches and mechanisms are envisaged according to existing plans: for the structure of agricultural production as a whole, for the introduction of innovative and resource-saving technologies, taking into account the limited land and water resources as well as the constant growth of the population of the Republic and the effectiveness of traditional agricultural methods. The scenario takes into account:

1. Implementation of the Program of measures for the integrated development of agriculture for the period 2016-2020[59], which proves for the creation of the necessary conditions for the further development of agricultural production, optimizing the structure of cultivated areas, ensuring rational use of land and

[59] Decree of the President of the Republic of Uzbekistan No. 2460 of December 29, 2015 "On measures for further reform and development of agriculture for the period 2016-2020."

water resources, introducing new advanced agricultural technologies for agricultural crops, the efficiency and financial sustainability of farms, as well as strengthening the export potential.

According to this program for the period 2016-2020 it is envisaged to:

- Rationally use and effectively manage land resources, e.g. by increasing the efficiency of land and water resources use by optimizing the structure of the cultivated areas of the main agricultural crops, reducing the area of cotton by 185.5 thousand hectares and the area of grain-crops 50.0 thousand hectares;
- Place potatoes (36.0 thousand hectares), vegetable (101 thousand hectares), fodder (50.9 thousand hectares) and oilseeds (15.2 thousand hectares), new intensive gardens (20.8 thousand hectares) and other crops (12 thousand hectares), using innovative methods of cultivation;
- Develop and approve a technological mapping regarding the production of agricultural crops, taking into account the introduction of modern intensive resource- and water-saving agrotechnologies;
- Further develop the seed production of agricultural crops to create early-ripening and high-yielding varieties, introducing scientific achievements in agricultural production, and improving the breeding in livestock raising;
- Improve primary seed production of potatoes on the basis of biotechnologies, and introduce the reproduction methods of meristems by organizing the production of potato seeds of elite classes through biotechnologies at the Institute of Bioorganic Chemistry. Create a biotechnology laboratory in the Research Institute of Vegetable Cereals and Potatoes and establish experimental stations in Djizak, Namangan, Samarkand and Tashkent regions for the production of a cutting-edge research, as well as four insulated greenhouses;
- Create specialized seed-growing farms to grow vegetable and melon seeds on an area of 12 thousand hectares and a gradual increase in seed production of high-yielding varieties and hybrids resistant to different climatic conditions;
- Widely apply advanced intensive agricultural technologies for agricultural production, introduce modern resource and water saving technologies, introduce effective crop rotation etc.;
- Improve the system of human resource training, raise the qualification of breeders and seed producers, provide regular seminars and trainings, expand the experience sharing experiences with developed countries.

2. According the Strategy of actions for the further development of the Republic of Uzbekistan for the period 2017-2021,[60] the following measures are envisaged in the field of rational and effective use and sustainable management of land resources to optimize crop acreage:

[60] Decree of the President of the Republic of Uzbekistan. No. 4947 dated February 7, 2017.

- Developing intensive horticulture and viticulture through cultivating high-yielding, early ripening dwarf and semi-dwarf vineyards by introducing modern agrotechnology, including:
- Intensivizing step-by-step the practices in the existing low-profit orchards and vineyards (transitioning annually 10% or 26.4 thousand hectar of gardens and 14.1 thousand hectar of vineyards);
- Introducing a drip irrigation system on newly created orchards and vineyards: every year for 5.7 thousand hectares of cultivated area;
- Increasing the number of dwarf and semi-dwarf seedlings and rootstocks suitable for the soil and climatic conditions of the Republic: at least 7 million pieces;
- Obtaining a high yield and income in dehkan farms and private part-time farms by the efficient and rational use of land plots; introduction of modern technologies and methods of farming;
- Planning the allocation of crops for a long-term period, through the introduction of crop rotation;
- Expanding research to create new agricultural crop varieties, which are suitable to the soil and climatic conditions of the Republic, as well as resistant to drought, salinity, heat and disease, etc.

The implementation of these and other measures in the agriculture sector will ensure the further strengthening of the food security and self-sufficiency of the Republic with the main food products, as well as a significant growth in exports of these products, which are on demand in foreign markets.

Ensuring the sustainable and balanced development of agriculture based on the effective use of land and water resources, reorienting agricultural production from extensive towards intensive growth factors.

For the period 2015-2020, an increase in the production of gross agricultural output of 1.5 times is projected at an average annual rate of 6.1%. However, given the higher growth rates in the industrial and service sectors, the share of agriculture in GDP is expected to decrease from the current 17% to 13% in 2020.

During this period, crop production is expected to grow 1.4 times, livestock production 1.6 times.

Growing production rates are expected for sectors such as poultry (6.1 times), fish farming (2.9 times), beekeeping (2.1 times).

By the end of 2019:

- the production volume of vegetable products per capita will be 336 kg compared to the current 293 kg; fruits, berries and grapes will be 161 kg (compared to currently 127 kg); potatoes will be 101 kg (compared to currently 79 kg);

- the number of cattle will increase by 37.8%, small cattle by 25.8%, poultry by 54%, which will increase overall meat production by 27.6%, milk production will increase by 31% and egg production by 61%. The implementation of the above measures will ensure by 2019 an increase in the per capita meat production by 7.1 kg (from currently 37.3 to 44.4 kg), milk by 60 liters (from currently 277 to 337 kg), eggs by 80 pieces (from 158 to 238 pieces).

At the same time, taking into account the limitations of land and water resources, the achievement of these targets will require:

a) Increasing the efficiency of land use through:

- *optimizing the allocation and improving the structure of cultivated areas*, taking into account the soil quality, the selection of the most productive crops that are in demand on the domestic and foreign crop markets.

The phased reduction of cotton crops on lands where its yield does not exceed 10 centners per hectar - which are being replaced with fruit, vegetables and fodder crops on 95,000 hectares - will not only keep the total cotton production in the country at the level of 3.1-3.2 million tons, but will also increase fruit and vegetable production by 4,623 thousand tons, and will increase fodder crops by 19 thousand hectares.

Table 8. Sowing areas of fruit crops in 2015-2019

	2015			2019 (projected)			Difference between 2015 and 2019, +/-	
	Total garden area, thousand hectares	Share of intensive gardens, thousand hectares	Share in %	Total garden area, thousand hectares	Share of intensive gardens, thousand hectares	Share in %	Share of intensive gardens, thousand hectares	Share in %
Republic of Karakalpakstan	5.6	0.04	0.7	7.1	0.5	7.7	0.5	7.0
area:								
Andijan	29.3	1.30	4.4	30.3	7.8	25.6	6.5	21.2
Bukhara	11.5	0.49	4.3	12.6	1.7	13.8	1.2	9.5
Jizzakh	13.7	0.74	5.4	15.4	4.1	26.8	3.4	21.4
Kashkadarya	19.2	1.34	7.0	21.0	6.3	30.2	5.0	23.2
Navoi	5.6	1.19	21.2	6.0	3.8	63.7	2.6	42.5
Namangan	27.2	1.88	6.9	28.2	13.9	49.5	12.1	42.6
Samarkand	32.3	2.91	9.0	33.3	15.8	47.6	12.9	38.6
Surkhandarya	14.9	0.88	5.9	16.9	4.9	29.0	4.0	23.1
Syrdarya	6.1	0.11	1.8	7.9	0.6	8.0	0.5	6.3
Tashkent	34.2	2.54	7.4	35.2	15.0	42.8	12.5	35.4
Fergana	47.6	0.55	1.1	48.6	2.4	4.9	1.8	3.7
Khorezm	12.7	0.13	1.0	13.7	1.0	6.9	0.8	5.9
Total:	**259.9**	**14.10**	**5.4**	**276.0**	**78.0**	**28.3**	**63.9**	**22.8**

- *Expanding fodder crop areas* by 19 thousand hectares and increasing the production of mixed fodders by 16 thousand tons, which allows to increase the number of livestock by 8,967 thousand head, meat production by 27.6%, and milk by 30.7%.
- *Improving the condition and fertility of soils.* It is planned to repair and construct over 4.1 thousand km of channels, 2,189 km of closed horizontal drainage network, 1,074 vertical drainage wells and 45 reclamation pumping stations, as well as repairing and restoring more than 89 thousand km of channel/drainage network, plus providing water management organizations with up-to-date land-reclamation equipment of up to 1,000 units. For these purposes, about 1,800.0 billion soum are required.

Table 9. Projected construction and reconstruction of reclamation facilities for 2015-2020, financed from the Reclamation Fund for Improvement of Irrigated Lands

№	Activities		2015-2020	2015	2016	2017	2018	2019	2020
1	**Construction and repair of channels, total:**	**km**	**4 142.6**	**710.1**	**720.0**	**712.0**	**690.0**	**673.0**	**637.5**
	including:								
	main	km	215.3	39.2	40.0	40.0	34.6	30.3	31.2
	inter-district	km	852.2	102.9	155.0	181.5	141.8	141.7	129.3
	inter-farm	km	3 075.1	568.0	525.0	490.5	513.6	501.0	477.0
2	**Construction and repair:**								
	closed horizontal drainage network	km	2 189.1	395.6	394.0	370.0	357.6	340.2	331.7
	vertical drainage wells	unit	1 074	197	205	190	172	160	150
	reclamation pumping stations	unit	45	6	4	8	10	8	9
	observation networks	unit	5 648	1 081	725	822	1 040	1 010	970
	hydro constructions	unit	283	31	44	44	50	54	60

Table 10. Projected repair and restoration of reclamation facilities for 2015-2020, financed from the Fund for Reclamation Improvement of Irrigated Lands

№	Activities		2015-2020	2015	2016	2017	2018	2019	2020
1	**Repair works on open collector-drainage systems, total:**	**km**	**89 489.9**	**15 339.0**	**16 279.0**	**17 305.0**	**12 666.2**	**13 607.3**	**14 293.4**
	including:								
	main	km	212.0	13.0	22.0	23.0	47.2	51.2	55.6
	inter-district	km	2 146.0	463.0	512.0	506.0	263.7	173.9	227.4
	inter-farm	km	87 131.9	14 863.0	15 745.0	16 776.0	12 355.3	13 382.2	14 010.4
2	**Repair and restoration work on:**								
	closed horizontal drainage networks	km	8 306.7	1597.0	1753.0	2230.0	861.8	866.8	998.1
	vertical drainage wells	unit	3 735	815	793	796	430	455	446
	reclamation pumping stations	unit	177	27	24	24	32	36	34
	hydrotechnical structures of reservoirs (dyker, aqueduct etc.)	unit	1 163	199	180	186	190	203	205
	tubular crossings	unit	9 207	1385	1375	2223	1403	1396	1425

b) Increasing the efficiency of water resources use by *introducing modern water-saving technologies, phased modernization of pumping and power equipment, reconstruction of irrigation facilities, effective water resources management.*

To this end, in the assessed period, it is required to introduce a drip irrigation system in all areas of gardens and vineyards, which will save about 1 billion m^3 of irrigation water.

Table 11. Projected savings of irrigation water when introducing drip irrigation technologies

	Total area of gardens and vineyards, thousand hectares	Irrigation water consumption, million m^3		Saved irrigation water, million m^3
		with traditional watering	with drip irrigation	
Republic of Karakalpakstan	6.2	31.2	15.6	15.6
area:				
Andijan	33.3	166.5	83.3	83.3
Bukhara	21.2	106.0	53.0	53.0
Jizzakh	17.7	88.5	44.3	44.3
Kashkadarya	30.2	151.0	75.5	75.5
Navoi	12.1	60.5	30.3	30.3
Namangan	38.3	191.5	95.8	95.8
Samarkand	71.0	355.0	177.5	177.5
Surkhandarya	29.3	146.5	73.3	73.3
Syrdarya	7.7	38.5	19.3	19.3
Tashkent	52.3	261.5	130.8	130.8
Fergana	53.0	265.0	132.5	132.5
Khorezm	15.4	77.0	38.5	38.5
Total:	**387.7**	**1938.7**	**969.3**	**969.3**

It is required to modernize 1,899 electric motors with a power of 110-2500 kW, which will save more than 370.0 million kWh of electric power and increase the water availability of about 450.0 thousand hectares of irrigated land, as well as to renew 1,283 pumps with a capacity from 0.3-2.0 m^3/s, which will save about 75.0 million kWh of electricity and increase water availability of about 250.0 thousand hectares of irrigated land.

It is required to construct and repair 361 pumping stations (causing energy savings of 73.0 million kWh), and to reconstruct 286.0 km of pressure pipelines.

It is required to carry out repair and restoration works of 13,047 pumping units and 7,797 irrigation wells; and 14,904 pumping units are scheduled for repair and restoration works at the expense of water user associations and farms.

Due to the implementation of these measures, the water availability will increase by about 1.5 million hectares and it is planned to save 950.0 million kWh of electricity (in 2015: 66.0 million kWh, in 2016-2018: 382.0 million kWh, in 2019-2020: 502.0 million kWh).

***c) introduction of modern agrotechnologies**, taking into account the best achievements in seed production and breeding.*

Work will continue to develop varieties of cotton, grain and vegetable s that are water-saving, salt-tolerant and resistant to biological pests. A special emphasis should be placed on introducing widely the already established high-yielding potato variety "superelite".

In the field of animal husbandry, work will continue to improve the breeding, to introduce scientific developments in breeding in livestock, to increase highly productive pedigree cattle by 55-60 thousand heads. This will increase the share of breeding cattle by 30% and bring its share to a total volume of 56%.

Table 12. Growth of breeding stock of cattle in personal subsidiary plots, dehkan farms and farms 2016-2019

	2015			2019 (projected)			Difference: +, -		
	Total	Share of pedigree cattle	share in %	Total	Share of pedigree cattle	share in %	Total	Share of pedigree cattle	share in %
Republic Karakalpakstan	989	288	25	1 289	710	55	300	422	30
area:									
Andijan	955	300	27	1 236	710	57	280	409	30
Bukhara	1 158	354	27	1 503	851	57	346	497	30
Jizzakh	799	244	27	1 046	591	57	246	347	30
Kashkadarya	1 346	411	26	1 749	989	57	403	578	30
Navoi	433	119	24	562	301	54	128	181	30
Namangan	670	184	23	874	467	53	204	283	30
Samarkand	1 534	465	26	1 998	1 125	56	464	660	30
Surkhandarya	894	251	24	1 170	632	54	277	382	30
Syrdarya	374	115	27	482	273	57	108	158	30
Tashkent	823	235	24	1 076	587	55	254	352	30
Fergana	945	294	27	1 231	703	57	286	409	30
Khorezm	894	251	24	1 141	616	54	246	366	30
Total	**11 170**	**2 867**	**26**	**15 355**	**8 557**	**56**	**4 186**	**5 690**	**30**

4.3 Mitigation Scenario

The mitigation scenario, in addition to the conditions and measures of the baseline scenario, takes into account:

1. Development and improvement of farm management. Practice has shown that the type of farm organization can greatly impact effectiveness of agricultural production in Uzbekistan. At the same time, as a result of the

agrarian reform, a new social group emerged that has high incentives and motivation for productive work and for increasing the efficiency of land and water resources in the agricultural sector.

At the same time, the climatic conditions, the growing scarcity of irrigated lands, caused by the water supply of the agrarian sector, require a more thoughtful approach to the specialization of farms.

The experience of recent years has shown that multi-product farms demonstrate the greatest financial stability, because - depending on the weather conditions and market requirements - they can more flexibly rearrange their production towards more demanded crops; and can - in case of losses for one type of agricultural produce – compensate this with higher incomes from other products.

The existing Uzbek Council of Farmers was abolished and replaced with an Uzbek Council of Farmers, Dekhan Farms and Individual Owners of Land[61], to implement measures for farmers, and considering the current deepening democratization of society, as well as the further reforming and liberalizing of the economy, which enhances the role and importance of farms.

In the coming years, farm development will be carried out by expanding the number of multi-profile farms. In this reagard, normative acts will be approved defining the status of multi-profile farms, defining contractual and legal relations among farms and khokimiyats (municipal goverments), as well as the relation with agriculture-relevant enterprises.

It is particularly important to improve the credit system for agricultural production. For 2008-2014, farms were allocated credits totaling US$ 1.1 billion equivalent to implement their activities and investments. During 2015-2019 the annual growth of credits from commercial banks for agricultural farm production should be at least 145%, which will support not only the stable growth of agricultural production, but also the financial stability of farms.

2.Creation of modern clusters for the cultivation of raw cotton and the production of other agricultural products, to further process raw products and to produce competitive products by remaining attractive for existing financing organizations and by attracting foreign direct investment, as well as direct investments of commercial banks.[62]

[61] Decree of the President of the Republic of Uzbekistan No. 5199 of 9 October 2017 "On measures to radically improve the system of protecting the rights and legitimate interests of farmers, dehkan farms and landowners, efficient use of agricultural acreage."

[62] Decree of the Cabinet of Ministers of 25.03.2017. No. 158 "On measures to organize in the form of an experiment of deep processing of raw cotton in the Kiziltepinskiy district, Navoi region", the Decree of the President of the Republic of Uzbekistan of 19.05.2017. No. PP-2978 and from 15.09.2017. No. PP-3279 for the creation of a modern cotton-textile cluster in the Syrdarya and Bukhara regions.

The aims at further deepening structural reforms and reducing the role of the state in agricultural production, stimulating direct investments, introducing effective methods for growing raw cotton and producing other agricultural products, organizing their further processing, as well as increasing productivity and wages in the agrarian sector.

At an initial stage, these measures are being implemented in the Navoi, Syrdarya and Bukhara regions.

Agricultural clusters can freely manage their own production, independently determine the pricing policy and the volume of their sales products. At the same time, the clusters have access to the terms and procedures for acquiring and leasing agricultural machinery, supply of mineral fertilizers, seeds, fuel and lubricants, chemical plant protection and other farming material.

In terms of the provision of state support, agricultural clusters are exempt from customs payments (except for customs duties) until 1 January 2022 regarding imported equipment, special vehicles, animals and plants not raised in the Republic of Uzbekistan, veterinary drugs, as well as other farming components, raw material and construction material, greenhouses for their own production needs within investment projects.

Table 13. Investment projects implemented in cotton-textile clusters 2017-2021

№	Name of investment project	Required I&FF (US$ million)	Annual capacity	Implementation time
1	Cultivation of raw cotton and other agricultural crops on an area of 26 thousand hectares	71.3	Raw cotton: 54 thousand tons, Fodder crops: 80 thousand tons	2017-2018
2	Production of raw cotton processing	5.5	Cotton fiber: 18.2 thousand tons, Seeds: 27 thousand tons	2018-2019
3	Production of fat and oil products on the basis of processing of technical seeds	3.8	Oil: 5.1 thousand tons, Meal: 12.3 thousand tons, Husks: 8.3 thousand tons, Soapstock: 517 tons	2018-2019
4	Production of ready-made textile and clothing products	90.0	Yarn: 15.2 thousand tons, Gauze: 120 million running meters, Fabric: 9 million running meters, Finished products: 31.5 million pieces	2018-2019
5	Animal breeding and poultry complex for the production and processing of meat, milk and eggs	34.5	Cattle: 15 thousand heads, Birds: 200 thousand heads	2017-2021
6	Modern greenhouse complex on an area of 120 hectares	65.0	Vegetables: 15 thousand tons	2019-2020
7	Production of processing of stems of cotton and local fertilizers of cattle-breeding complex	5.0	Biogas: 10 thousand meters^3, Biohumus: 43 thousand tons	2019-2020
8	Production of natural dyes	3.0	Natural dyes: 50 tons	2018-2020
9	Processing and storage of agricultural products	10.0	Prodessing: 10 thousand tons, Storage: 5 thousand tons	2017-2020

3. Increaseing the level of processing agricultural products. In order to increase the level of processing agricultural raw materials, to saturate the domestic market and to increase export potential, it is planned to implement 2015-2020[63] 330 investment projects in the food industry totaling US$ 438.54 million, with the creation of 2,271 new jobs, including:

- 131 projects for processing meat and milk products totaling US$ 89.9 million;
- 59 projects for processing fruit and vegetable raw materials in all regions of the country for a total amount of more than US$ 80.8 million;
- 29 projects for producing confectionery and food products for US$ 73.8 million;
- 111 projects in other branches of the food-processing industry for US$ 194.0 million.

As part of these measures, fruit and vegetable processing projects are implemented with the use of high innovative technology in the Andijan region; processed food is being prepared using freeze-dried preparations from vegetables and fruits in the Jizzakh region; fruits are processed using shock freezing in the Kashkadarya region; vegetables are freeze-dried in the Surkhandarya and Fergana regions; and food is being processed by shock freezing and the installation of modern refrigerating chambers in the Tashkent and Samarkand areas, among other initiativs.

[63] Resolution of the President of the Republic of Uzbekistan of 5.03.2016. No. PP-2505 "On measures to further develop the resource base, deepen processing of agricultural products, increase production and exports of food products in 2016-2020."

5. Results

An analysis of the above scenarios shows that the implementation of the action plan in the agriculture sector will help limit the negative consequences of climate change in the country. In particular:

1. Optimization of the allocation and improvement of the structure of acreage with a gradual reduction of cotton crops on lands where its yield does not exceed 10 centners per hectar and grain-crops with yields below 20 centners per hectar on a total area of 220.5 thousand hectares and and replacing them by food crops, which will increase the production of fruit and vegetable products by 4.056 million tons, and the production of fodder crops by 1,670 thousand tons and the production of oilseeds by 62 thousand tons. This will allow to generate an additional income of over 490 billion soum, instead of losses in the amount of over 270 billion soum due to climate change.[64] Also in terms of employment, instead of climate change induced losses in these areas, there will be an increase in employment of the population by 175,000 people.

2. Step-by-step replacement of existing old orchards and vineyards for intensive ones, as well as creating new intensive orchards and planting of fruits and vegetables on the liberated lands using high-tech agrotechnical measures. At the same time, the measures will allow to increase fruit yields at a minimum of 3-4 times only due to increasing the planted area and the share of high-yield intensive gardens from 5.4% or 14.1 thousand hectares in 2015 to 28.3% or 78 thousand hectares in 2019.

3. According to the results of the planned measures, improvement of the reclamation state of more than 1.4 million hectares of irrigated land is expected, including the reduction of lands with a critical level of groundwater occurrence by 310 thousand hectares (29%), and a reduction of heavily and medium saline lands by 80.2 thousand hectares (11.5%). A deterioration of the condition of about 970 thousand hectares will be prevented.

An increase in soil fertility will ensure an increase in crop yield by an average of 14-17% per year.

4. Increasing the export potential of the agricultural sector. Growth in the production of agricultural products, primarily fruits and vegetables, will create favorable conditions for a greater export orientation of the industry.

The total export volume of fresh and dried fruit and vegetable products is expected to gradually reach 2.1 million tons, or 11.4% in the total fruit and vegetable production. With the unique fruit and vegetable products, it should be aimed to develop markets not only for neighbouring countries, but also for the European Union, as well as for Asian countries like Korea and Japan.

[64] According to national experts.

At the same time, the creation of an export system requires a uniform supply of products throughout the calendar year. To this end, it is necessary to gradually create modern so-called 'dry ports' with refrigerating capacities for the simultaneous storage of up to 3 million fruit products, as well as to create an entire logistics system, including a procurement system, vehicles (refrigerated trucks and autotractors) and to identify the most efficient transport routes.

All this will increase the export of fruit and vegetable products by 2020 to a total of US$ 5 billion.

5. As a result of increasing the level of processing of agricultural products, it is expected to achieve:

- An increase in the volume of processing raw fruit, vegetable and grapes from 2,253.2 thousand tons to 3,327.8 thousand tons (147.7% by 2015), an increase in meat processing from 115.9 thousand tons to 275 thousand tons (by 2.4 times), as well as an increase in milk processing from 1058.4 thousand tons to 1795 thousand tons (1.7 times).
- Production of:
    - canned fruits and vegetables: 1 billion 192 million cans (2.1 times by 2015);
    - dried fruits: 256.7 thousand tons (1.7 times);
    - sausage products: 52.8 thousand tons (1.7 times);
    - milk and dairy products: 1 million 36.1 thousand tons (1.9 times);
    - butter: 17 thousand tons (1.8 times);
    - sugar: 610 thousand tons (1.5 times);
    - confectionery products: 98.2 thousand tons (2 times).

These measures will ensure an increase in production of food products per capita compared to 2015 for meat and meat products by 28.9%, in the production of milk and dairy products by 37.3%, fruit and vegetable preserves by 2 times, dried fruits by 58.5%, vegetable oil by 12.4%, sugar by 37%, and confectionery products by 186.8%.

Particular attention is paid to increasing exports of processed fruit and vegetable products. By 2019, the export of processed fruit and vegetable products is to be expected to reach:

- canned fruits and vegetables: 26 thousand tonnes (2.1 times more than 2015);
- fruit juices up: 31.5 thousand tonnes (1.9 times more than 2015);
- dried fruit: 135.2 thousand tonnes (1.7 times more than 2015).

6. Growing income and quality of life of the rural population. The social gap between rural and urban residents is decreasing, and this dynamic is being tracked. The reduction is a result of the measures to increase employment and income of the rural population, to improve the quality of their lives in recent years. Today the average per capita income of the rural population does not

differ from that of the urban resident, while in 2005 the gap between them was 1.2 times. As a result of the accelerated development of the service sector in rural areas, the gap between the average per capita urban and rural services has been almost halved over the past seven years (from 4.9 times in 2007 to 2.7 times in 2015).

In general, for 2007-2014, the Giny coefficient, which reflects the differentiation in the level of incomes of different population groups in a country, decreased from 0.32 to 0.29, which corresponds with the average level of the economically developed countries in the world.

The agricultural reforms aim at creating the most favorable conditions for the life of rural residents. By 2020, the income level of rural residents should grow by a factor of 1.7.

At the same time, rural residents will be fully equal in terms of access to services for school and secondary special education, health services, telecommunications, most types of communal and household services, like urban residents, and see significant improvements in transport infrastructure, especially roads.

Over the next five years, no less than 87,000 typical rural houses will be built, which will improve housing conditions and provide comfortable living conditions for 102,000 rural residents.

All new settlements will be provided with social, transport, communal infrastructure, trade and consumer services facilities, as well as new jobs in the newly created industrial and service facilities.

At the same time, as part of the implementation of the mitigation scenario, it is necessary to:

- Improve the legislation and regulatory framework in the field of administrative responsibility aimed at enhancing legal compliance of officials and other persons for mismanagement of lands, violation of the state land cadastre, leading to a decrease in soil fertility and land degradation;
- Introduce amendments and additions to the relevant legislative acts to further improve farm activities, and to effectively use their land areas, including definiting the legal status of multi-disciplinary farms;
- Implement financial mechanisms to encourage the introduction of renewable energies, to create favorable conditions for attracting investments, primarily foreign direct investment;
- Support the implementation of investment projects on resource-saving technologies, and on the production of technological equipment for drip irrigation.

Chapter III. ASSESSMENT OF INVESTMENT AND FINANCIAL FLOWS (I&FF) TO ADDRESS CLIMATE CHANGE IN THE SOCIAL SECTOR IN TEMRS OF DRINKING WATER SUPPLY

Introduction

The Republic of Uzbekistan has two main river basins: the Amudarya in the south and the Syr Darya in the north, which together form the Aral Sea basin.

The main river basin is the Amudarya river basin, which covers 86% of the entire territory of the Republic, and which consists of the tributaries Surkhandarya, Kashkadarya and Zarafshon, all originating in Tajikistan.

The average annual discharge of the Amudarya River basin is 78 km^3, and depends on annual precipitation.

Annual water discharge from the territory of Uzbekistan forms about 4.7 km^3 or 6% of the total surface water resources of rivers in the country.

The Syr Darya River covers 14% of the territory of the Republic. This is structured into the upper current in Kyrgyzstan - where the majority of the flow occurs -, the middle course in Uzbekistan and Tajikistan, and the lower current in Kazakhstan, followed by the confluence of the Aral Sea.

The main streams of the river basin are the rivers Karadarya, Naryn, Chirchik and Akhangaran. The average annual water flow of the Syrdarya river basin is 37 km^3 and depends on the water content of the year. The annual water resources in the territory of Uzbekistan form about 5 km^3 or 13% of the total surface resources of the river.

The distribution of water resources is controlled by the Interstate Coordinating Committee located in Tashkent, which was established by the governments of 5 states (Uzbekistan, Kazakhstan, Tajikistan, Kyrgyzstan and Turkmenistan). The Committee coordinates and monitors compliance with bilateral interstate agreements.

In accordance with these agreements, Uzbekistan receives water from transboundary rivers originating in Tajikistan and Kyrgyzstan, and also passes on water for Kazakhstan, Tajikistan and Turkmenistan.

Legislative and legal framework of the sector "Drinking water and natural sources of water supply". Main laws on water supply and sanitation are:

I.

- The Constitution of the Republic of Uzbekistan of 1992, where Article 55 states that land, water, minerals, airspace, flora and fauna and other natural resources are the property of the people and should be used rationally and protected by the state.
- The Law of the Republic of Uzbekistan "On Water and Water Use" was adopted in 1993. In 2007, amendments were made to Articles 41 and 42 concerning centralized and decentralized water supply and to include the main state responsibilities in providing water supply services and water quality surveillance.
- The Law on Natural Monopolies was put into effect in 1997. In 2007, amendments were made. This law determines the role of the state in regulating natural monopolies. Urban water supply and sanitation enterprises are classified as natural monopolies. By-laws determine a 10% maximum rate of profit for water utilities, which can be included in the tariff. Relevant is the Law of the Republic of Uzbekistan No. 363 of 27 December 2013 "On Environmental Control".

The climate change impact on drinking water availability, water resources management and projected future trends and their possible decision scenarios had not yet been studied, since such tasks had not yet been set. It would be desirable in subsequent years for Tashkent‘s Institute of Irrigation and Land Reclamation of Agriculture to carry out such studies jointly with the Center for Economic Research.

The legislative framework encompasses that the laws, regulations, standards, sanitary rules and norms in force in the country apply to all organizations of the country engaged in drinking water and protection of water supply sources. The above laws and other regulations are valid in the same way for all national institutions. However, these laws and regulations were adopted before climate change became part of the political agenda and do not yet address future climate change. In the context of this legislative framework, the results of this assessment will be practically implemented, which will create the opportunity to increase access to drinking water in spite of climate change.

II.

- Resolution of the Cabinet of Ministers of the Republic of Uzbekistan No. 98 of 26 March 2007 on measures to implement the project "Improving the water supply system in Gulistan, Jizzakh and Karshi" with the participation of the Asian Development Bank.
- Resolution of the Cabinet of Ministers of the Republic of Uzbekistan No. 218 of 4 May 2007 "On the Program of Water Conservation and Rational Use of Water Resources in the Republic of Uzbekistan for the Period to 2020".

- Resolution of the President of the Republic of Uzbekistan No. PP-555 of 8 January 2007 on measures to implement the project "Water supply and sanitation of rural settlements of Navoi and Kashkadarya regions" with the participation of the Asian Development Bank.

III.

- State Standard of the Republic of Uzbekistan O'zDST 950: 2011 "Drinking water. Hygienic requirements and quality control".
- State Standard of the Republic of Uzbekistan O'zDST 951: 2011 "Sources of centralized domestic and drinking water supply. Hygienic, technical requirements and rules of choice."

IV.

- Approved sanitary norms, rules and hygienic standards SanPiN RUz No. 0172-04: Sanitary and hygienic requirements for the protection of surface water sources from pollution in Uzbekistan. Tashkent, 2004. 12s.
- Approved sanitary norms, rules and hygienic standards SanPiN Ruz No. 0200-06: Sanitary rules and norms of hygienic assessment, determination of classes of surface and underground water sources, their choice for centralized household and drinking water supply to the population of Uzbekistan. Tashkent, 2006. 8s., 35.
- Approved sanitary norms, rules and hygienic standards SanPiN RUz No. 0173-04: Sanitary and hygienic requirements for the protection of underground water sources against pollution in Uzbekistan. Tashkent, 2004. 5s.
- Approved sanitary norms, rules and hygienic standards SanPiN RUz No. 0182-05: Hygienic requirements for water quality of non-centralized water supply and sanitary protection of sources in Uzbekistan. Tashkent, 2005. 9c.
- Approved sanitary norms, rules and hygienic standards SanPiN RUz No. 0202-06: The procedure for issuing permits for special water use, development and harmonization of projects on substances coming from sewage into water bodies and on the terrain. Tashkent, 2006. 8s.
- Approved sanitary norms, rules and hygienic standards SanPiN RUz No. 0211-06: Hygienic criteria and water quality control of centralized systems of domestic and drinking water supply of the population of Uzbekistan. Tashkent, 2006. 10s.
- Approved sanitary norms, rules and hygienic standards SanPiN RUz No. 0255-08: The main criteria for hygienic assessment of the degree of water contamination of aquatic facilities for health hazards in Uzbekistan. Tashkent, 2008. 7c.
- Approved sanitary norms, rules and hygienic standards SanPiN RUz No. 0256-08: Hygienic requirements for water treatment processes in the systems of centralized household-drinking water supply in Uzbekistan. Tashkent, 2008. 9c.

Administrative division of the country. The administrative division of the Republic consists of the sovereign Republic of Karakalpakstan and 12 regions, 119 cities, 1,085 urban settlements, 168 districts and 11,012 rural settlements.

Table 1. Administrative units of regions

Regions	Cities of regional subordination	Districts	Cities of regional subordination	Villages
In the Republic, total:	**26**	**168**	**91**	**11012**
Republic Karakalpakstan	2	14	10	1 128
area:				
Andijan	2	14	9	456
Bukhara	2	11	9	1 469
Jizzakh	1	12	5	519
Kashkadarya	1	13	11	1 045
Navoinskaya	2	8	4	577
Namangan	1	11	7	403
Samarkand	2	14	9	1 829
Surkhandarya	1	13	7	865
Syrdarya	3	8	2	257
Tashkent	4	14	11	885
Fergana	4	15	5	1 020
Khorezm	1	10	2	559
Tashkent city		11		

Demographic situation. Uzbekistan is the largest state in Central Asia in terms of its population. As of 01.01.2015 the population was 31,023 thousand people. The largest part of the population is urban: 15,748 thousand people, and rural: 15,275 thousand people.

Table 2. Population in the regional context (thousand people)

Regions	Total population	City population	Rural population
Total for the Republic:	**31 023.0**	**15 748.0**	**15 275.0**
Republic Karakalpakstan	1 763.1	921.2	841.9
area:			
Andijan	2 857.3	1 532.2	1 325.1
Bukhara	1 785.4	678.4	1 107.0
Jizzakh	1 250.1	589.6	660.5
Kashkadarya	2 958.9	1 274.5	1 684.4
Navoinskaya	913.2	448.5	464.7
Namangan	2 554.2	1 618.8	935.4
Samarkand	3 514.8	1 337.0	2 177.8
Surkhandarya	2 358.3	845.2	1 513.1
Syrdarya	777.1	336.6	440.5
Tashkent	2 758.3	1 350.2	1 408.1
Fergana	3 444.9	1 965.9	1 479.0
Khorezm	1 715.6	559.1	1 156.5
Tashkent city	2 371.3	2 371.3	

Source: State Statistics Committee of the Republic of Uzbekistan, 2016.

Uzbekistan belongs to a region with a high birth rate, especially in rural areas. Therefore, rapid population growth causes additional problems associated with the provision of drinking water. Not only new activities for water resources

management in the country are required, even now there is a shortage of drinking water.

Coverage of water supply services. According to statistics, the level of coverage of centralized water supply services in Uzbekistan in 2017 reached about 80.2%: 89.3% in urban areas and 69.3% in rural areas (see table 3 below wih **data of the agency "Uzkommunkhizmat").**

The highest coverage percentage of centralized water supply services was registered in the city of Tashkent (99.5%), as well as in the cities of Samarkand, Fergana and Andijan regions (about 93-98%). The lowest percentage coverage in urban areas is observed in the Jizzakh region (75%).

As for the rural population, the highest coverage is in the Ferghana and Andijan regions (80-87%), and the lowest among the rural population of the Bukhara and Khorezm regions (42.4% and 56.8% respectively), which clearly reflects the lack of fresh surface and groundwater resources in these two areas.

In 8,910 rural settlements (out of 11,012) there is a centralized water supply.

Table 3. Provision of apartments (houses) with drinking water (in %, by state)

Regions	as of 01/01/2016			as of 01/01/2017		
	Total	in urban areas	in rural areas	Total	in urban areas	in rural areas
Republic of Uzbekistan	**81.4**	**89.9**	**71.1**	**80.2**	**89.3**	**69.3**
Republic of Karakalpakstan *region*:	67.7	73.3	61.3	66.6	72.0	60.5
Andijan	91.9	94.2	89.6	90.4	93.3	87.2
Bukhara	57.7	83.7	43.4	56.6	82.9	42.4
Jizzakh	70.3	75.8	65.9	68.9	74.9	64.2
Kashkadarya	73.9	86.6	62.9	72.8	85.7	61.7
Navoi	80.1	84.2	73.3	78.7	83.8	70.2
Namangan	77.5	85.4	66.8	76.1	85.0	64.5
Samarkand	86.6	98.1	77.3	85.8	98.1	75.9
Surkhandarya	80.5	84.4	78.1	78.5	83.3	75.5
Syrdarya	82.4	80.0	84.2	81.6	79.7	83.1
Tashkent	78.8	85.2	70.9	77.7	84.8	69.0
Fergana	89.8	94.2	83.3	88.8	93.9	21.5
Khorezm	67.5	83.5	58.2	66.3	82.9	56.8
City of Tashkent	100.0	100.0	-	99.5	99.5	-

Source: Agency Uzkommunkhizmat, 2016.

The main goal of this work is the assessment and analysis of investment and financial flows to address climate change adaptation, increasing the efficiency of water use of natural fresh water sources in the context of climate change in Uzbekistan.

1. Objectives

To achieve this goal, the following tasks have been accomplished in the course of the assessment:

- Determining the boundaries of the sector by drinking water and water supply sources;
- Identifying of adaptation measures in the sector;
- Assessing investment and financial flows of the historical period (2006-2014);
- Identifying scenarios of future sector development (baseline scenario and adaptation scenario);
- Determining investment and financial flows for the baseline scenario and the adaptation scenario (2015-2025);
- Conducting a comparative data analysis of the baseline and adaptation scenarios;
- Evaluating the policies for implementing adaptation measures.

1.1. Justification

1.1.1. Previous Analyses Utilized

In this work various materials of international environmental conferences, seminars and meetings, as well as the results of international and national projects were used. These include:

The most significant documents were used for the assessment, especially official documents and materials of the Ministry of Agriculture and Water Resources of the Republic of Uzbekistan, as well as official documents and project materials of the Ministry of Housing and Communal Services of the Republic of Uzbekistan. It is in these documents that all the necessary information is needed for this assessment.

1. The Nukus Declaration of the States of Central Asia and International Organizations on the Problems of Sustainable Development of the Aral Sea Basin (September 1995), signed by the heads of all five countries, which in particular states:
"We declare our full support for international agreements, in particular, the Declaration on Sustainable Development (Rio de Janeiro, 1992), the World Charter of Nature, the International Conventions to Combat Desertification, the Climate Change Convention, the Conservation of Biological Diversity and on the protection of transboundary waters. In addition, we consider it necessary to create an international convention on the sustainable development of the Aral Sea basin. The issues of joint water use and unification of environmental standards and related legislation should take priority in this."

2. "Adaptation to climate change. Examples from Uzbekistan and Kazakhstan." UNDP, Tashkent, 2012.

3. The impact of climate change on water resources in Central Asia (Synthesis Report), Almaty, 2009.

4. The results of the "Second National Communication on the United Nations Framework Convention on Climate Change", where a vulnerability analysis of the most important economic sectors and ecosystems was carried out, and recommendations were made for preparatory measures to adapt to possible climate change.

5. "National Action Plan of the President of Uzbekistan for Environmental Protection".

6. United Nations Development Program Project in Uzbekistan "Improvement and development of a database of environmental indicators using GIS for monitoring the state of the environment in Uzbekistan" Environmental review of Uzbekistan, Tashkent, 2009.

7. The Third National Communication of the Republic of Uzbekistan on the UN Framework Convention on Climate Change, Tashkent, 2016.

8. Official documents and materials of the Ministry of Agriculture and Water Resources of the Republic of Uzbekistan.

9. Official documents and materials of the Ministry of Housing and Communal Services of the Republic of Uzbekistan.

The assessment of investment and financial flows of the sector "drinking water and natural sources of water supply" is considered a priority. The economic policy of Uzbekistan planned for the near future envisages:

- providing the population with safe drinking water, especially in rural areas;
- preventing further anthropogenic pollution of natural underground and surface sources of water supply;
- fully covering the population of the Republic by systems of centralized household and drinking water supply;
- ensuring stable high growth rates of agricultural production;
- boosting the development of industries whose products will contribute to increasing the export potential;
- fundamentally renewing the equipment and technical basis of water supply and sewerage.

The fulfillment of these tasks largely depends on the current state of water resources and its projected future change. Consequently, the consideration of

the issues of the impact of climate change on the state of water resources is of great social and national economic importance, as indicated by the social development in Uzbekistan, and by the requirements to ensure safe conditions for water use of the population, the sustainability of agriculture and the need to meet the growing needs of the population of food products.

Therefore, all adaptation measures considered in this work aim at protecting natural water bodies in Uzbekistan and their rational use considering the anticipated climate change, which will guarantee providing the population with quality drinking water, and providing the economy and agriculture with the necessary amount of water resources.

In this work, for the first time in Uzbekistan an attempt was made to assess the investment and financial flows and determine their required amount and allocation to fully meet the growing needs of the population and national economy to address the expected climate change.

For this purpose, the following adaptation activities are being considered in the sector assessment "Drinking water and natural sources of water supply":

- Allocating appropriate capital investments for the construction of water pipes and sewerage systems in cities and districts, building water supply networks;
- Constructing inter-district and communal rural water pipelines;
- Identifying I&FF for repair and restoration work at water supply facilities for 2018-2025;
- Providing equipment and technical facilities for rural water pipelines (including the centralized acquisition of desalination plants, chlorinators of various systems, and bactericidal lamps);
- Improving the sanitary and technical level of equipment and operation of non-centralized water intakes in those rural settlements where they are still used by a significant part of the population, including work on sanitary equipment of wells, installation of pumps, water-valves on wells, springs, tanks and reservoirs for water storage;
- Introducing a drinking water system for the population in cities and rural settlements on the basis of a differentiated tariff policy (regarding the cost of drinking water), taking into account the recovery of operation and maintenance costs;
- Developing and improving existing regulatory legal documents in the field of sanitary protection of water supply sources and assessment of drinking water quality in accordance with the requirements of international sanitary standards, rules and norms;
- Mobilizing external financing sources of water supply systems for the population and for the protection of water bodies (priority projects are the development of inter-regional water pipelines);
- Improving water resources management (transition to Integrated Water Resources Management);
- Optimizing the distribution of agricultural production, taking into

account the country's needs for specific agricultural products and minimizing water use (important to consider developing an economic and mathematical model for optimizing the allocation of agricultural production);
- Introducing progressive irrigation methods (drip, sprinkling) and improving existing (traditional) methods;
- Constructing additional reservoirs;
- Reconstructing existing and construction of new hydraulic structures, which ensure the reduction of losses and a rational use of water etc.;
- Carrying out selection work on growing drought-resistant crops;
- Exploring possibilities of using additional water resources (poorly mineralized collector-drainage water, groundwater and sewage) and their quantitative potential.

The measures proposed above are developed by the expert team of the social sector "Drinking water and natural sources of water supply" in the course of this assessment.

1.1.2. Institutional Arrangements and Collaborations

Institutional and cooperation issues between various organizations were discussed at the beginning of this work. A number of intersectoral meetings were organized with the main ministries, departments, organizations and scientific research institutes of the Republic of Uzbekistan, represented by the heads of departments and leading researchers. The following organizations and institutions took part in intersectoral meetings:

- Center for Economic Research under the Service for the Coordination of Social and Economic Policy of the Office of the President of the Republic of Uzbekistan;
- Ministry of Agriculture and Water Resources of the Republic of Uzbekistan;
- Committee on Hydrometeorology under the Cabinet of Ministers of the Republic of Uzbekistan;
- Ministry of Housing and Communal Services of the Republic of Uzbekistan;
- Ministry of Health of the Republic of Uzbekistan;
- Scientific Research Institute of Irrigation and Water Problems;
- Committee of the Republic of Uzbekistan for Environmental Protection and Nature;
- Scientific Research Institute of Sanitation, Hygiene and Occupational Diseases.

The above organizations are the main owners of the necessary information on the problems of drinking water and natural sources of water supply, water management in Uzbekistan and all reporting information for the historical period, and also future programs are concentrated in these organizations. In

addition, the Center for Ecoomic Research and the Scientific Research Institute of Irrigation and Water Problems are the developers of State scientific and technical programs on water and economic problems and are experienced solving problems related to assessing natural resources quality, drinking water and water supply systems, included in the adaptation activities in this assessment. Much infestment flow data was received from the Agency "Uzkommunkhizmat" (now the Ministry of Housing and Communal Services of the Republic of Uzbekistan). The financial flow data was calculated by the Center for Economic Research together with the Scientific Research Institute for Irrigation and Water Problems and the Ministry of Housing of the Republic of Uzbekistan.

In addition, the following sources were used to determine the values of possible investments necessary to obtain representative data:

- Consolidated standards of specific capital investments for construction;
- Reconstruction of land reclamation systems and facilities;
- American experience of trenchless repair of underground pipelines, Moscow - 1997 (Levitin);
- Rules of technical operation for systems and structures of public water supply and sewerage, Moscow - 1999. Published by "Soyuzvodokanalproekt";
- Designing water supply systems and facilities, Moscow - 2005. Publishing house "INFO", (Zhurba);
- Economic calculations of operation and maintenance for equipment of water supply and sanitation systems, Moscow - 2007 (Zhmakov).

1.1.3. Basic Methodologyand Key Terminology

This assessment uses the "Methodological handbook on assessing investment and financial flows to address climate change, Section IX" Assessment of I&FF for adaptation in the water sector" by UNDP, 2009.

The following official documents were also used in this work:

- "Strategy of social and economic development of the Republic of Uzbekistan for the period until 2025", where the main data of economic development up to 2025 is presented;
- "National Action Plan for the Protection of the Environment and Natural Environment of Uzbekistan for 2017-2021";
- "The Third National Communication on the United Nations Framework Convention on Climate Change", Tashkent, 2016;
- Statistical reports on the Republic of Uzbekistan, where the current data of socio-economic development for 2007-2016 is presented;
- Reports of the Ministry of Agriculture and Water Resources of the Republic of Uzbekistan, the Agency "Uzkommunkhizmat", the Research Institute for Economic Development under the Cabinet of Ministers of the Republic of Uzbekistan, the Scientific Research Institute of Irrigation

and Water Problems for 2007-2016.

The baseline scenario and the adaptation scenario were based on results of the "Second National Communication on the UN Framework Convention on Climate Change" regarding information on the water balance, namely, the expected change in river runoff and surface evaporation from reservoirs, as well as the increasing irrigation rate for agricultural crops. In addition, the information of the Bioclimatic Atlas of Central Asia was used and the data over the past 10 years by Uzgidromet (Center of Hydrometeorological Service at the Ministry of Emergency Situations) of Uzbekistan.

Uzbekistan's climatic conditions are one of the determining factors in the formation of the hydrological network and have a significant impact on the conditions of water use by the population.

Uzbekistan is located in the steppe zone and is characterized by a strongly continental arid climate, which is due to the remoteness of the territory from large water areas, the prevalent dry air of the deserts of Central Asia in the warm season, and the low moisture of the Arctic air in the cold half of the year. Winters are short, cold with unstable snow cover, significant wind speeds, and they last from mid-December to February. Summers are long with high temperatures and very dry air.

The duration of the period of the year with an average daily air temperature of no higher than 0°C is on average 230-250 days. Fluctuations in air temperature during the day reach up to 24-28°C.

The average annual relative humidity ranged from 50.9-65.5%, differing insignificantly in the cities studied. At the same time, up to 48-52% of precipitation falls in summer and autumn months. The average long-term level of precipitation is 189-242 mm, out of which 79.9-92.2% falls on the winter-spring periods. Precipitation of the winter-spring period is of great importance in the supply of surface and groundwater, and during the warm period of the year precipitation is almost completely used up by evaporation and by nutrition of plants. On average, the annual share of days with a precipitation of less than 0.5 mm is 56-59%. The share of days with precipitation exceeding 10 mm does not exceed 1.8-2.7%.

In a multi-year perspective, the amount of precipitation varied widely. For a long period three peaks were recorded, when the amount of precipitation exceeded 250 mm. The uneven dynamics of cloudiness caused a considerable duration of sunshine, which averaged 4,600 hours per year. Most sunshine takes place in the summer months, when 82.2-87.4% of the total sunshine duration occurs.

The natural conditions and geographical processes in Uzbekistan are also largely determined by the nature of the relief. In its orographic sense, it is clearly divided into two parts: a large western part, in which the Turanian plain

and the eastern plain lay, occupied by the mountain systems of the Tien Shan and the Pamirs. A significant part of the plains with different reliefs lies on average at an altitude of 100-300 m above sea level.

According to the data an increase in air temperature is expected throughout the territory of Uzbekistan, as well as a decrease in the amount of precipitation. However, the change rate in temperature and precipitation may be different in different years, depending on the time horizon of the projection. Calculations show that the temperature increase by 2025 can be on average 1.5-2°C relative to the base temperature. The calculations are confirmed by the Hydrometeorological Service of Uzbekistan (UzHydromet): During the preparation of the Second and Third National Communications, various approaches were used to develop climate scenarios: In the "Second National Communication", the following general atmospheric circulation models were used: GISS, CCCM, UK89, GFDL-R-30. In the "Third National Communication", the MAGICC/SCENGEN software package recommended by the IPCC was used, where based on the results of 10 general atmospheric and ocean circulation models, the most suitable models were selected for the territory of Uzbekistan and the information was used based on the results of these models. It is understood that in the territory of Uzbekistan the air temperature increase until 2025 will be in the range of 1.5–2°C.

The analysis allows to draw the conclusions that by 2025:

- The flow of rivers will decrease: in the Amudarya by 7-12%, and in the Zeravshan by 5-8%. Especially important is that against a background of 5-15% reduction in the annual runoff of local rivers, the runoff during the vegetation period may be reduced by up to 30% due to the water analysis for agricultural needs. Decreases in runoff are expected: for the Surkhandarya River by 30%, for the river Kashkadarya by 50%, for the Sherabadarya River by 20%, for the Akhangaran River by 10%, and for the Chirchik River by 8%. The absolute total reduction in runoff will be about 3,400 million m^3;
- Evaporation volumes from the surface of reservoirs will increase by 150 million m^3 compared to the base year;
- Irrigation requirements for agricultural crops will increase by 20% by 2025, leading to a requirement of an additional 5,000 million m^3;
- The mineralization of water supply sources will increase by 25%;
- The deficit drinking water will increase by 30%;
- The deficit of water supply system complying with sanitary norms will be 25%.
- Up to 40% of the water supply networks of centralized drinking water systems will not meet the sanitary requirements;
- The equipment and technical accessories of water pipes (desalination plants, chlorators of various systems, bactericidal lamps, water fluoridation plants, mobile laboratories, etc.) will deteriorate by 25%.

The data given here are based on a temperature change of 1.5-2°C in

Uzbekistan. This information builds a basis for the methodoloy and both scenarios and is therefore highlighted here.

The baseline scenario takes into account the fact that natural (underground and surface) and artificial (water reservoirs, irrigation canals, hydrotechnical constructions) sources of water supply to industry, population and agriculture of Uzbekistan is a national property that plays a big role in the socio-economic development of the Republic. Irrigation canals and reservoirs are sources of water supply for the population, used for households, drinking and cultural water supply, watering livestock and pastures, as well as for fish farming. Water supply is also important for various industries, agriculture, energy and transport, domestic and recreational purposes, as well as for addressing a number of other needs. The Republic of Uzbekistan constantly lacks water resources. Therefore, to ensure an equitable distribution of available water resources between consumers in different regions and between different users, Uzbekistan takes responsibility for managing water resources and planning its further use to fully meet the water requirements of the population and the national economy of the Republic.

The sector "Drinking water and natural sources of water supply" is being developed in accordance with its development programme. However, due to specific conditions, such as the current economic situation in the Republic, the state of the international food market, the state of agriculture, population growth, the development of free economic zones, and the construction of agricultural and industrial enterprises, this programme is often adjusted. When adjusting the programme, priority measures are set, and usually the average level of development of water management is maintained. The last corrected plan is 100% financed from the budget of the Republic and is always carried out in full. This is the basis for the baseline scenario.

Therefore, the methodical approach for the baseline scenario until 2025 is based on the average development data of the sector "Drinking water and natural sources of water supply". Thus, the scale and growth rate of investment and financial flows, as well as operation and maintenance cost until 2025 are expected to continue in the same dynamics as in the historical period 2006-2014.

The adaptation scenario takes into account optimization of water supply, efficient functioning of centralized water supply systems, improvement of the conditions for water use, to provide the population with safe drinking water, and provide the Uzbek economy with sufficient water resources, which are important economic tasks that require a major effort on the part of the state. As part of this assessment, experts calculated the possible water shortage due to climate change in Uzbekistan and suggested possible adaptation measures to cover this deficit. In the adaptation scenario, the size of the investment and financial flows as well as operation and maintenance costs was estimated by the experts as the minimum level necessary for achieving the established goals and to address climate change. This scenario assumes additional efforts to develop

the sector "Drinking water and natural sources of water supply" to be prepared for climate change.

Although the activities in the baseline scenario and adaptation scenarios are similar, they differ in scale and in pace of implementation.

Compared to the baseline scenario, the target scenario (adaptation scenario), takes into account additional adaptation measures.

The a***daptation scenario*** takes into account that a temperature increase in Uzbekistan by an average of 1.5-2°C would lead to a deterioration in water use conditions by about 20%. This will lead to a malfunction in the operation of centralized drinking-water supply systems, the quality of drinking water will deteriorate significantly, and the pollution levels of sources of drinking water use will increase.

On this basis, for specific activities envisaged in the adaptation scenario, the amount of their implementation and financing will be increased in comparison with the baseline scenario. In connection with the above, the main data was selected, which is given in the baseline and adaptation scenarios. However, in the adaptation scenario, an increase in investment is planned for the selected list of measure in the sector "Drinking water and natural water sources". The following measures were selected: Water channels, water supply networks, wells, water towers, reservoirs, pumping stations, chlorination plants.

To assess the future I&FF of adaptation activities for the period up to 2025, projections of required I&FF were developed. This also applies to operation and maintenance costs. In addition, government programmes and plans for water sector development and similar current projects were reviewed to assess future investments in specific activities. Among these programmes and plans are the following:

1. "Strategy of integrated development and modernization of water supply and sewage systems of the Republic of Uzbekistan until 2025" and other material identifying the objetives and parameters to develop the sector "drinking water and natural sources of water supply";
2. "Programme for the development of agriculture in Uzbekistan until 2025. Water management system";
3. "The concept of developing reliable and safe drinking water supply of the Republic of Uzbekistan until 2025";
4. "Regulations on organizing construction and repair of water supply and sanitation facilities financed by public capital investments".

In instances where it was difficult to assess I&FF, e.g. in terms of official data on the financial flows of training, seminars, business trips within Uzbekistan and foreign countries, the organization of meetings, etc., expert judgement was used from professionals of relevant organizations involved in water supply and protection of water bodies.

Key terms:

"Investment flows" (IF) are capital expenditures for new physical assets with a service life of more than one year, for example, capital expenditures for the construction of water pipes, reservoirs, wells, water conduits, treatment plants, etc.

"Financial flows" (FF) are ongoing flows associated with scientific and program activities; financial flows include expenses other than those related to the expansion or introduction of new physical assets. Examples of financial flows include research and development (grants), development of computer programs, training of employees in new research methods, conducting seminars, traveling around the country and abroad, distributing popular literature, etc.

"Investment entity" is an organization that is responsible for investments. These are organizations that decide and disburse on investment activities.

"Sources of I&FF" are the origins of funds used by investment entities, for example, domestic capital, foreign debt, domestic subsidies, or foreign aid.

"Operation and maintenance costs" (O&M) - in our understanding, these include:

- Salary of staff;
- Fuel cost, i.e. energy and/or fuel for operations or production;
- Utilities, such as telephone services, internet connection, etc.;
- Raw materials;
- Operating costs such asequipment leasing;
- Office supplies and consumables;
- Advertising;
- Licenses or equivalent fees (i.e. an annual registration fee for corporations) charged by the government;
- Costs for real estate, including:
    - Lease payments;
    - Office areas;
    - Furniture and equipment;
    - Property taxes and equivalent taxation;
    - Operational duties, i.e. duties levied on transport carriers for the use of roads, as well as production or operational duties;
    - Insurance;
    - Damage due to losses in the absence of insurance, accidents, sabotage, negligence or terrorism.

2. Scope

2.1. Scope of the Drinking Water Supply Secor

As mentioned above, almost all surface and underground water bodies are used in Uzbekistan to supply the population with drinking water, providing 72% of the urban population and only 61% of the rural population with drinking water. In this regard, for this assessment the scope was to increase the coverage of the population with potable water and access to water supply sources through the implementation of additional measures.

The systems of centralized household and drinking water supply include a complex set of facilities, comprising water intake facilities, reservoirs for settling the water, as well as units where water is purified, processed, disinfected and supplied to the population by water distribution networks. In Uzbekistan, there is also a system of decentralized water supply, where the population uses tubular wells for drinking purposes. To date, there are 383 municipal and 4,114 departmental water pipelines in Uzbekistan. Of these, 9.7% of communal water pipelines and 17.9% of rural water pipelines do not meet sanitary requirements (data of the Ministry of Health of the Republic of Uzbekistan).

In this context, measures were selected characterizing the scope of the sector "Drinking water and natural sources of water supply", including: investment and financial flows for the construction and repair of water pipes, water supply networks, wells, water towers, tanks, pumping stations, chlorinator installations and fences. In addition, the scope of this assessment also included particularly important drinking water facilities, such as the construction of interregional water pipelines, the construction of treatment facilities for water pipes and sanitary protection zones of water networks.

It is also relevant to consider drinking water aspects in the Republic of Uzbekistan due to the following factors:

- Improving the conditions for water use and providing the population with centralized water supply systems will make it possible to effectively address problems of social and environmental tension in the Republic;
- More than 20% of water resources are used in the sector "Drinking water and natural water sources";
- The adaptation measures implemented in this sector will make it possible to provide the population with safe drinking water, rationally use natural water resources and reduce the number of fatal water-related incidences;
- Socio-economic development and food security of Uzbekistan largely depends on the ecological state of natural water sources and the quality of drinking water, and therefore the importance of this sector is beyond doubt.

It should be noted that in Uzbekistan 80% of water resources are used for irrigation and agriculture needs. These agricultural issues are covered however in the sector assessment "Agriculture" above, not in this assessment to avoid overlaps and double-counting.

In terms of investment entities, it should be noted **that the only source of investment in the water sector in Uzbekistan is the state.**

For the development of the water infrastructure, large amounts of capital investments are allocated by funds of the agency "Uzkommunkhizmat" (Uzbekistan Communal Services Company), the Ministry of Agriculture and Water Resources of Uzbekistan, the state budget, the State Monetary Fund, the State Committee for Environmental Protection and Nature of Uzbekistan and other state agencies.

In the historical period and at present, certain financial flows included: carrying out research on public scientific and technical programs (through grants), holding project seminars supported by international organizations (UNDP, UNEP, USAID, GEF etc.), as well as training and skills development at the national level and abroad. The information on financial flows presented in the tables is based on mapping data and expert judgement, and therefore some information to implement activities in the target scenario (adaptation scenario) may be associated with uncertainties.

3. Data Input and Scenarios

3.1. Assessment Period and Cost Accounting Parameters

The assessment was carried out with a time horizon of 2025. The historical period covers data for 2006-2014. Information has been collected from: the Agency Uzkommunkhizmat (now the Ministry of Housing and Communal Services of the Republic of Uzbekistan), the Ministry of Agriculture and Water Resources of Uzbekistan, the Center for Economic Research under the Service for the Coordination of Social and Economic Policy of the Office of the President of the Republic of Uzbekistan and the Scientific Research Institute of Irrigation and Water.

In the Republic, various branches of the economy and industry are using different currencies, depending on: the level of their external economic relations, the level of state financing, self-supporting relations in the industry, the economic state of related industries, the historically established order of planning in the industry, and the planning of spending of financial resources. For the assessment of the sector "Drinking water and natural sources of water supply" it was decided to compile financial information only in the national currency "soum". At the same time, a number of especially important and costly facilities connected with: the construction of interregional water pipelines, reservoirs, pumping stations, treatment facilities by international financial organizations, such as the Asian Development Bank, the Bank, the International Monetary Fund, are funded in US$. Thus, the financial plans that exist in US$ were not converted to soum.

In Uzbekistan, the entire national strategy for developing the drinking water supply system was approved at the level of the President of the Republic of Uzbekistan until 2025. All information on investments up to 2025 in the sector "Drinking water" were used from the Agency "Uzkommunkhizmat", as well as from the Ministry of Agriculture and Water Resources of the Republic of Uzbekistan.

The assessment used information in the national currency soum, because the investment entity of the historical period, as well as for the scenarios is the state.

3.2. Analytical Approach

The methodological approach in the baseline scenario is based on the current growth rate of expenditures for 2006-2014, and based on this (in the same dynamics), the projection was carried out until 2025. As indicated above, the peculiarity of the sector "Drinking water and natural sources of water supply" in

Uzbekistan that all investments are covered by the state budget. For the scenarios it is assumed that in future this will remain the same. However, it will not be possible to maintain the investment growth rate until 2025 to implement adaptation measures that guarantee a 100% coverage of the population by centralized drinking-water supply systems and safe watere conditions in the face of climate change.

Based on this, an adaptation scenario was calculated based on the implementation of specific measures to reduce the negative impact of climate change on natural sources of water supply and drinking water by 2025. This served as the basis for determining the investment and financial flows needed to implement the measures.

In the absence of numerical information on investment and financial flows for some measures for 2022-2025, methods of medium-term forecasting were used.

The dependencies between the variables is analyzed in a retrospective way (for the historical period), and used for the assessment of the baseline scenario, and is subsequently used for the calculation of investment and financial flows of the target scenario (adaptation scenario).

The methodological approach used simple calculations, such as extrapolating historical data into the future for the assessed time horizon, as well as complex methods such as regression models for analyzing the dependence of investment and financial flows in the adaptation scenario (2022-2025) compared to the historical data.

In this case, the construction of regression models was preceded by calculating correlation coefficients, which represent an empirical measure of linear dependence between variables characterized by the sum of investment and financial flows for a retrospective (historical) period. After obtaining the correlation coefficient, its significance is checked. At the same stage, regression models are constructed using the method of least squares. The construction of such models is effective when there is a sufficiently close correlation between the investment and financial flows of the measures, if the length of the retrospective period is sufficient for constructing a trend. The trend (deterministic component) is expressed by an approximation function that reflects the development patterns of the process being assessed. This function is carried out on the basis of minimum mean square deviation by the time series method. The close correlation between the values of investment and financial flows for the historical period of 2006-2015 and the baseline scenario corresponded to linear equations of $Y = A + BX$, where: Y = adaptation time period, A = investment and financial flows for the historical period, B = regression coefficient, X = investment and financial flows in the target (adaptation) scenario.

The main activities and parameters to develop centralized and non-centralized drinking water supply systems were determined by the Center for Economic

Research under the Service for the Coordination of Social and Economic Policy of the Office of the President of the Republic of Uzbekistan, the Ministry of Housing and Communal Services, the Ministry of Agriculture and Water Resources and the Scientific Research Institute of Irrigation and Water Problems. At the same time, key documents were consulted such as: "Strategy of integrated development and modernization of water supply and sewerage systems of the Republic of Uzbekistan until 2025", "Concept of development of reliable and safe drinking water supply of the Republic of Uzbekistan until 2025", "Regulations on the organization of construction and reconstruction of water supply facilities financed by state capital investments", and "Agricultural Development Programme of Uzbekistan until 2025". These documents were used by experts to determine the list of adaptation measures in the sector "Drinking water and natural sources of water supply" to address climate change and increasing water shortage.

3.3. Historical IF, FF and O&M Data

Historical data on investment and financial flows (2006-2014) are provided according to the data of the Agency "Uzkommunkhizmat" (now the Ministry of Housing and Communal Services of the Republic of Uzbekistan" (see table).

Historical data on investment and financial flows are presented:

- from materials mapping scientific research works conducted during the historical period;
- known costs of developing various programs;
- known expenses for the development of new research methods for protecting reservoirs and drinking water;
- information for the assessed time period gathered during business trips nationally and aborad;
- workshops conducted on topics of drinking water;
- literature for the public on the protection of water bodies and drinking water use of the population;
- expert judgement.

Table 4. Historical data by types of investments
(in million Uzbek soum)
Investment entity = Government
Sources of I&FF = Domestic Budget

	Water pipes			Water supply networks			Wells			Water towers			Tanks			Pumping stations			Chlorination plants		
	IF	FF	O&M	IF	FF	O&M	IF	FF	O&M	IF	FF	O&M	IF	FF	O&M	IF	FF	O&M	IF	FF	O&M
2006	1.5	0.5	0.2	6.8	0.0	0.0	10.2	0.0	0.0	1.4	0.4	0.2	1.2	0.0	0.0	1.0	0.0	0.0	1.3	0.5	0.3
2007	4.3	0.9	0.2	1.9	0.0	0.0	3.6	0.0	0.0	4.1	0.8	0.3	3.4	0.0	0.0	2.9	0.0	0.0	3.8	0.7	1.1
2008	3.0	0.7	0.2	1.3	0.0	0.0	2.5	0.0	0.0	2.7	0.6	0.4	2.3	0.0	0.0	2.0	0.0	0.0	2.6	0.8	0.8
2009	3.5	0.6	0.3	1.5	0.0	0.0	2.8	0.0	0.0	3.2	0.5	0.4	2.6	0.0	0.0	2.3	0.0	0.0	3.0	0.6	0.4
2010	3.1	0.5	0.2	1.3	0.0	0.0	2.5	0.0	0.0	2.9	0.5	0.3	2.4	0.0	0.0	2.0	0.0	0.0	2.7	0.4	0.2
2011	7.4	1.2	0.4	3.3	0.0	0.0	6.2	0.0	0.0	7.0	1.1	0.7	5.8	0.0	0.0	4.9	0.0	0.0	6.6	0.9	0.3
2012	8.9	1.4	0.5	3.9	0.0	0.0	7.4	0.0	0.0	8.4	1.3	0.9	6.9	0.0	0.0	5.9	0.0	0.0	7.9	1.0	0.9
2013	21.7	3.2	0.5	9.6	0.0	0.0	18.1	0.0	0.0	20.5	9.1	1.1	16.9	0.0	0.0	14.5	0.0	0.0	19.3	4.2	1.3
2014	23.4	3.4	0.7	10.4	0.0	0.0	19.5	0.0	0.0	22.1	3.2	1.0	18.2	0.0	0.0	15.6	0.0	0.0	20.8	4.3	1.5
Total	**76.8**	**12.4**	**3.3**	**40.0**	**0.0**	**0.0**	**72.8**	**0.0**	**0.0**	**72.3**	**11.5**	**5.3**	**59.7**	**0.0**	**0.0**	**51.1**	**0.0**	**0.0**	**68.0**	**13.4**	**7.4**

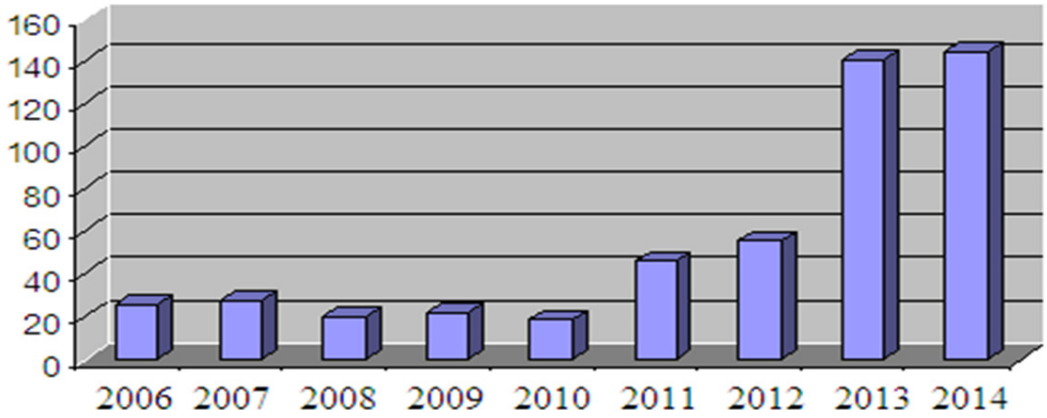
Table 5. Historical data, total I&FF
(in million Uzbek soum)
Investment entity = Government
Source of I&FF = Domestic Budget

	Water pipes IF+FF+O&M	Water supply networks IF+FF+O&M	Wells IF+FF+O&M	Water towers IF+FF+O&M	Tanks IF+FF+O&M	Pumping stations IF+FF+O&M	Chlorination plants IF+FF+O&M
2006	2.2	6.8	10.2	2.0	1.2	1.0	2.1
2007	5.4	1.9	3.6	5.2	3.4	2.9	5.6
2008	3.9	1.3	2.5	3.7	2.3	2.0	4.2
2009	4.4	1.5	2.8	4.1	2.6	2.3	4.0
2010	3.8	1.3	2.5	3.7	2.4	2.0	3.3
2011	9.0	3.3	6.2	8.8	5.8	4.9	7.8
2012	10.8	3.9	7.4	10.6	6.9	5.9	9.8
2013	25.5	9.6	18.1	30.7	16.9	14.5	24.8
2014	27.5	10.4	19.5	26.3	18.2	15.6	26.6
Total	**92.5**	**40.0**	**72.8**	**95.1**	**59.7**	**51.1**	**88.2**

It can be seen from the tables that in the last years of the "historical" period there has been an increase in investment (see Table 5). This situation can be explained by the desire of the government of the Republic to improve the water use conditions for the population and to generally improve the economic welfare of the Republic as a whole. It should be noted that in the entire historical period, the toal I&FF and O&M for the construction of water pipes was 92.5 million soum; the total for water supply networks was 40.0 million soum; the total for wells was 72.8 million soum; for water towers was 95.1 million soum, for reservoirs 59.7 million soum; for pumping stations 51.1 million soum; for chlorinated plants 88.2 million soum (see Table 5).

The total amount of financial flows for the entire historical period is 499.4 million soum. At the same time, the percentage of construction costs for water pipelines was 18.5%, for water supply networks it was 8.2%, for wells it was 14.5%, for water towers 19%, for reservoirs 12%, for pumping stations 10.2% and for chlorination plants it was 17.6%.

Figure 1. I&FF in the historical time period (in million soum)



4. Scenarios

4.1. Baseline Scenario

As indicated above, investment flows for the historical period (2006-2014) was based on the data of the Agency "Uzkommunkhizmat" and the Ministry of Agriculture and Water Resources of Uzbekistan. An analysis of financial flows has shown that implementing adaptation measures under the baseline scenario is expected to reduce by 40% the problems associated with improving drinking water supply systems and drinking water quality by 2025. At the same time, the total amount of I&FF for 2015-2025 calculated at current real costs will amount to about 4,286.2 million soum, including:

- Construction, reconstruction and repair of water pipelines: 807.4 million soum;
- Construction, reconstruction and repair of water supply networks: 350.0 million soum;
- Construction and repair of wells: 631.8 million soum;
- Construction of water towers: 683.7 million soum;
- Construction of reservoirs: 623.3 million soum;
- Construction, reconstruction and repair of pumping stations: 521.3 million soum;
- Construction, reconstruction and repair of chlorination plants: 668.7 million soum.

Table 6. Measures of the baseline scenario (million soum)

Measures	Total I&FF	% of total I&FF
Water pipes	807.4	19.0
Water supply networks	350.0	8.5
Wells	631.8	14.9
Water towers	683.7	15.7
Tanks	623.3	14.3
Pumping stations	521.3	12.2
Chlorinated installations	668.7	15.4
Total	**4 286.2**	**100.0**

It should be noted that according to the Agency "Uzkommunkhizmat", some foreign financial organizations have provided investments in the sector "Drinking water, natural sources of water supply". These investors include the International Development Bank, the Asian Development Bank, the Arab Coordination Group, and the World Bank.

The International Development Bank invests US$ **210.79** million, the Asian Development Bank US$ **131.45** million, the Arab Coordination Group US$ **87.17** million, and the World Bank US$ **323.40** million. At the same time,

it should be noted that the level of foreign investments in the Republic of Uzbekistan for the indicated years does not exceed 10-12%**. It should also be noted that due to the lack of information on foreign investments for 2017-2025, it is difficult to project foreign investment levels for the adaptation scenario.**

Table 7. Foreign investments in the sector "Drinking water and natural sources of water supply" (US$ million)

Year	International Development Bank	The Asian Development Bank	The Arab Coordination Group	The World Bank for Development
2007	2.20	5.80	3.12	18.10
2008	3.00	7.20	3.17	19.20
2009	3.90	7.90	4.20	19.10
2010	3.31	11.20	5.60	25.60
2011	0.00	14.50	11.10	27.30
2012	15.23	17.90	12.70	31.40
2013	28.51	19.10	14.20	34.00
2014	39.76	20.50	16.30	49.50
2015	41.57	23.50	10.78	49.90
2016	73.31	23.85	6.00	50.20
Total	**210.79**	**131.45**	**87.17**	**323.40**

This information will be kept separate from the historical data from national sources, due to the fact that these will be uncertain to project until 2025. In addition, foreign currency is provided only for the construction of interregional water pipelines, and there is no breakdown available by measures, as they are listed in the tables for the baseline and adaptation scenarios.

Table 8. Baseline scenario, by types of investments
(in million Uzbek soum)
Investment entity = Government
Source of I&FF = Domestic Budget

	Water pipes			Water supply networks			Wells			Water towers			Tanks			Pumping stations			Chlorination plants		
	IF	FF	O&M	IF	FF	O&M	IF	FF	O&M	IF	FF	O&M	IF	FF	O&M	IF	FF	O&M	IF	FF	O&M
2015	43.7	6.1	3.6	19.4	2.6	1.9	36.4	2.9	0.9	41.3	2.4	1.7	34.0	4.5	2.6	29.1	3.3	1.9	38.9	3.9	1.9
2016	45.6	6.4	3.7	20.2	2.8	1.6	38.0	3.1	1.4	43.0	1.6	1.2	35.4	4.2	2.4	30.4	3.6	1.2	40.5	3.8	1.7
2017	50.6	6.3	4.2	22.4	1.9	1.7	42.0	2.2	2.6	47.8	0.9	1.6	39.3	4.9	2.2	33.7	2.4	1.4	44.9	3.6	0.6
2018	55.7	5.1	4.6	24.7	2.1	1.4	46.4	3.6	1.6	52.6	0.8	1.9	43.3	4.6	2.7	37.1	3.7	1.6	49.5	3.7	0.8
2019	49.7	5.4	3.7	22.1	2.4	1.6	41.4	3.2	1.8	47.0	0.4	2.4	38.7	4.7	2.4	33.1	3.2	1.7	44.2	2.8	0.9
2020	51.7	5.7	3.9	22.9	1.6	1.1	43.0	3.1	1.6	48.8	0.7	1.2	40.2	4.8	2.5	34.4	2.7	1.8	45.9	2.6	1.2
2021	63.7	6.6	4.9	28.3	1.9	1.2	53.1	2.1	2.1	60.1	0.6	0.9	49.5	4.9	2.6	42.4	3.9	1.9	56.6	2.9	1.2
2022	76.9	6.7	5.0	34.2	2.9	1.3	64.1	2.4	2.2	72.6	1.4	0.6	59.8	5.1	3.1	51.3	5.5	1.7	68.4	3.4	0.9
2023	82.6	5.4	5.1	36.7	2.2	1.2	68.8	2.6	2.1	78.0	1.2	0.8	64.3	5.2	2.9	55.1	3.2	1.8	73.4	3.6	1.4
2024	85.7	5.2	4.9	38.1	2.8	1.4	71.4	2.8	1.9	80.9	0.8	1.9	66.6	5.4	3.4	57.1	3.6	1.9	76.2	3.7	1.4
2025	88.2	5.3	5.5	39.2	2.6	1.6	75.5	2.1	2.4	83.3	0.9	2.4	68.6	5.3	3.2	58.8	4.6	2.2	78.4	4.6	1.2
Total	**694.1**	**64.2**	**49.1**	**308.2**	**25.8**	**16.0**	**580.1**	**31.1**	**20.6**	**655.4**	**11.7**	**16.6**	**539.7**	**53.6**	**30.0**	**462.5**	**39.7**	**19.1**	**616.9**	**38.6**	**13.2**

Table 9. Baseline scenario, total I&FF
(in million Uzbek soum)
Investment entity = Government
Source of I&FF = Domestic Budget

	Water pipes IF+FF+O&M	Water supply networks IF+FF+O&M	Wells IF+FF+O&M	Water towers IF+FF+O&M	Tanks IF+FF+O&M	Pumping stations IF+FF+O&M	Chlorination plants IF+FF+O&M
2015	53.4	23.9	40.2	45.4	41.1	34.3	44.7
2016	55.7	24.6	42.5	45.8	42.0	35.2	46.0
2017	61.1	26.0	47.8	50.3	46.4	37.5	49.1
2018	65.4	28.2	51.6	55.3	50.6	42.4	54.0
2019	58.8	26.1	46.4	49.8	45.8	38.0	47.9
2020	61.3	25.6	47.7	50.7	47.5	38.9	49.7
2021	75.2	31.4	57.3	61.6	57.0	48.2	60.7
2022	88.6	38.4	68.7	74.6	68.0	58.5	72.7
2023	93.1	40.1	73.5	80.0	72.4	60.1	78.4
2024	95.8	42.3	76.1	83.6	75.4	62.6	81.3
2025	99.0	43.4	80.0	86.6	77.1	65.6	84.2
Total	**807.4**	**350.0**	**631.8**	**683.7**	**623.3**	**521.3**	**668.7**

4.2. Adaptation Scenario

The adaptation scenario considers the implementation of additional adaptation measures to address climate change. As indicated above, with expected temperature increased of 1.5-2°C, climate change may lead in Uzbekistan to a deterioration in water use conditions by about 40%. This will lead to a malfuncting operation of centralized drinking water supply systems, and drinking water quality will deteriorate significantly, wile the pollution levels of drinking water sources will increase. Based on this, for the selected measures envisaged in the adaptation scenario, the required I&FF for their implementation was identified and compared to the baseline scenario. The selected adaptation measures, determined by experts, include:

- construction of new reservoirs, for accumulation of fresh water and for flood water;
- construction of storage facilities for rainwater accumulation;
- introduction of recycled water supply at industrial facilities;
- use of household and collector-drainage wastewater on agricultural irrigation fields;
- introduction of modern purification methods for industrial wastewater at enterprises of various industries;
- organization of sanitary protection zones for water supply facilities and sources of centralized domestic and drinking water supply;
- development of measures to prevent and protect water bodies for drinking purposes from further anthropogenic pollution;
- artificial replenishment of underground freshwater resources;
- improvement of monitoring drinking water quality and water supply sources;
- development of measures to prohibit the discharge of industrial wastewater into drinking-water reservoirs, if the effluents contain chemicals for which hygienic standards have not been established.

- improvement of water resources management (transition to Integrated Water Resources Management);
- optimizing the distribution of agricultural production, taking into account the country's needs for agricultural products and minimizing the use of water resources (here it is necessary to consider the development of an economic and mathematical model for optimizing the allocation of agricultural production);
- construction of additional reservoirs and increasing the capacity of existing reservoirs;
- reconstruction of existing and construction of new hydraulic structures, ensuring reduction of losses and the rational use of water etc.;
- carrying out selection work on growing drought-resistant crops;
- explore possibilities of developing additional water resources (poorly mineralized collector-drainage water, groundwater and sewage) and their quantitative potential.

For these measures, investment and financial flows were calculated until 2025.

The calculation showed that the implementation of the planned activities on the adaptation scenario by 2025 in the Republic of Uzbekistan **will allow to:**

- reduce the levels of anthropogenic pollution of natural water sources;
- provide the population with safe drinking water;
- improve the conditions for water use of the population;
- modernize the systems of centralized drinking water supply;
- provide the population with systems of decentralized water supply;
- reduce the cost of fresh water for irrigation of crops;
- optimize agricultural production;
- create new hydraulic structures for water storage;
- allocate additional financial resources for the implementation of the financial flows;
- use water resources for agriculture that is not for drinking purposes;
- create sanitary protection zones for water pipes and water sources.

The total amount of I&FF for 2015-2025 in the Republic will amount to 7 665.1 billion soum, of which:

- Construction, reconstruction and repair of water pipelines: 1,422.5 million soum;
- Construction, reconstruction and repair of water supply networks: 634.6 million soum;
- Construction and repair of wells: 1,1236 million soum;
- Construction of water towers: 1,230.1 million soum;
- Construction of reservoirs: 1,092.2 million soum;
- Construction, reconstruction and repair of pumping stations: 922.5 million soum;
- Construction, reconstruction and repair of chlorination plants: 1,239.6 million soum.

Table 10. Adaptation scenario, by types of investments
(in million soum)
Investment entity = Government
Source of I&FF = Domestic Budget

	Water pipes			Water supply networks			Wells			Water towers			Tanks			Pumping stations			Chlorination plants		
	IF	FF	O&M	IF	FF	O&M	IF	FF	O&M	IF	FF	O&M	IF	FF	O&M	IF	FF	O&M	IF	FF	O&M
2015	87.5	8.9	4.1	38.9	3.9	1.9	72.9	2.9	1.4	82.6	2.1	1.2	68.0	5.1	2.7	58.3	4.1	1.9	77.8	4.6	1.9
2016	91.1	8.7	4.2	40.5	3.7	1.8	75.9	3.6	1.6	86.0	2.1	1.1	70.8	5.2	2.8	60.7	4.2	1.8	81.0	4.9	2.2
2017	98.0	8.6	4.4	43.5	3.8	1.9	81.7	4.7	2.1	92.6	1.6	1.4	76.2	5.6	2.9	65.3	4.4	1.6	87.1	5.9	2.3
2018	94.8	8.1	4.6	42.5	3.7	2.1	79.0	4.7	2.2	89.5	1.2	0.9	73.7	5.7	2.6	63.2	4.6	1.7	84.3	6.7	0.9
2019	104.5	8.4	4.7	46.4	3.9	2.2	87.1	4.3	1.7	98.7	0.8	0.4	81.3	5.9	2.7	69.7	4.7	2.1	92.9	7.7	1.6
2020	113.7	8.6	4.2	50.5	4.1	2.4	94.8	2.9	1.9	107.4	0.9	0.6	88.4	6.1	2.7	75.8	4.2	2.1	101.1	6.9	0.7
2021	124.5	8.9	4.9	55.3	4.2	2.6	103.8	3.9	1.3	117.6	1.4	0.7	96.9	6.2	3.6	83.0	5.6	2.4	110.7	8.8	0.8
2022	132.7	9.2	5.2	58.9	4.6	1.9	110.5	3.6	0.9	125.3	0.8	0.4	103.2	5.4	3.2	88.4	4.9	1.9	117.9	9.2	1.7
2023	137.7	9.4	5.1	61.2	5.7	1.8	114.8	3.7	1.4	130.1	1.2	0.9	107.1	5.8	3.4	91.8	4.8	1.8	122.4	10.1	1.6
2024	142.9	9.2	3.2	63.5	5.1	1.9	119.1	4.7	1.6	134.9	2.2	0.8	111.1	6.9	4.6	95.2	4.9	1.6	127.0	11.2	1.9
2025	147.0	9.9	5.6	65.3	3.2	1.7	122.5	4.2	2.2	138.9	2.6	1.2	114.4	7.8	4.2	98.0	5.6	2.2	130.7	12.3	2.8
Total	**1274.4**	**97.9**	**50.2**	**566.5**	**45.9**	**22.2**	**1062.1**	**43.2**	**18.3**	**1203.6**	**16.9**	**9.6**	**991.1**	**65.7**	**35.4**	**849.4**	**52.0**	**21.1**	**1132.9**	**88.3**	**18.4**

Table 11. Adaptation scenario, total I&FF
(in million soum)
Investment entity = Government
Source of I&FF = Domestic Budget

	Water pipes IF+FF+O&M	Water supply networks IF+FF+O&M	Wells IF+FF+O&M	Water towers IF+FF+O&M	Tanks IF+FF+O&M	Pumping stations IF+FF+O&M	Chlorination plants IF+FF+O&M
2015	100.5	44.7	77.2	85.9	75.8	64.3	84.3
2016	104.0	46.0	81.1	89.2	78.8	66.7	88.1
2017	111.0	49.2	88.5	95.6	84.7	71.3	95.3
2018	107.5	48.3	85.9	91.6	82.0	69.5	91.9
2019	117.6	52.5	93.1	99.9	89.9	76.5	102.2
2020	126.5	57.0	99.6	108.9	97.2	82.1	108.7
2021	138.3	62.1	109.0	119.7	106.7	91.0	120.3
2022	147.1	65.4	115.0	126.5	111.8	95.2	128.8
2023	152.2	68.7	119.9	132.2	116.3	98.4	134.1
2024	155.3	70.5	125.4	137.9	122.6	101.7	140.1
2025	162.5	70.2	128.9	142.7	126.4	105.8	145.8
Total	**1422.5**	**634.6**	**1123.6**	**1230.1**	**1092.2**	**922.5**	**1239.6**

Analyzing the tables shows that the implementation of the adaptation scenario for 2015-2025 requires for a significant increase in I&FF to address climate change, a temperature increase by 1-2°C. The I&FF to implement the adaptation scenario from 2015-2025, are required to increase with an average annual growth of about 7%; for implementing measures to increase the coverage of the population with centralized water supply systems, to increase the reliability of municipal and departmental water pipelines, to increase the provision of safe drinking water to the population. This is supported by the fact that in this period the equipment and technical facilities, and the financial ability of the state for carrying out such acivities, will also significantly increase.

This situation is **confirmed** by results of calculations, which are set out in the table 12 below. It can be seen from the table that the required I&FF of the adaptation scenario for the water pipes will increase by 75.2% compared to the baseline scenario; water supply networks by 81.3%; wells by 77.8%; water towers by 79.9%; tanks by 75.2%; pumping stations by 76.9%; and chlorination plants by 85.3%.

Table 12. Measures of the adaptation scenario (in million soum)

Measures	Total I&FF	% of I&FF in relation to the baseline scenario
Water pipes	1422.5	75.2
Water supply networks	634.6	81.3
Wells	1123.6	77.8
Water towers	1230.1	79.9
Tanks	1092.2	75.2
Pumping stations	922.5	76.9
Chlorinated installations	1239.6	85.3
Total	**7,665.1**	**78.8**

The analysis of the above data shows that the implementation of a comprehensive plan of activities in the sector "Drinking water and natural sources of water supply" according to the adaptation scenario will allow to address the negative consequences of the expected climate change in the Republic. With total required I&FF of more than 7 billion soum, taking into account possible investments from other sources, for example, foreign financial institutions, the reliable operation of the sector "Drinking water and natural sources of water supply" will be raised to the required level. It should be noted that in the scenarios the most unfavorable scenarios of climate change were taken into account.

5. Results

The main result of this work is the first time ever analysis of investment and financial flows in the Republic of Uzbekistan in the sector "Drinking water and natural sources of water supply"; this is one of sectors most vulnerable to climate change, given temperatures are projected to rise nationally up to 2°C by 2025. Climate change, as mentioned above, can lead to unfavorable consequences in the sector, which will eventually contribute to an increase in the levels of anthropogenic pollution of water supply sources, to a deterioration of drinking water quality, to a sharp increase in related morbidity rates, and to a malfunction in the operation of centralized water supply systems.

Under such conditions, the social tension in the Republic is expected to increase significantly. The forecasted situation requires a set of measures as presented in the adaptation scenario (target scenario) that contribute to adapting to climate change in the sector "Drinking water and natural sources of water supply", to address the causes of potential failure in the operation of centralized drinking water supply systems and and to optimize the condition of water supply sources.

National specialists of the sector have acquired considerable experience and skills in conducting economic and financial analysis in the sector through the I&FF assessment. International experts from UNDP (Mrs. Susanne Olbrisch etc.) and other countries have repeatedly conducted seminars and trainings on a range of aspects of financial and economic analysis in other countries and in Uzbekistan; and - most importantly - handed over to the national experts of Uzbekistan the "Methodological handbook on investment and financial flows assessments to address climate change".

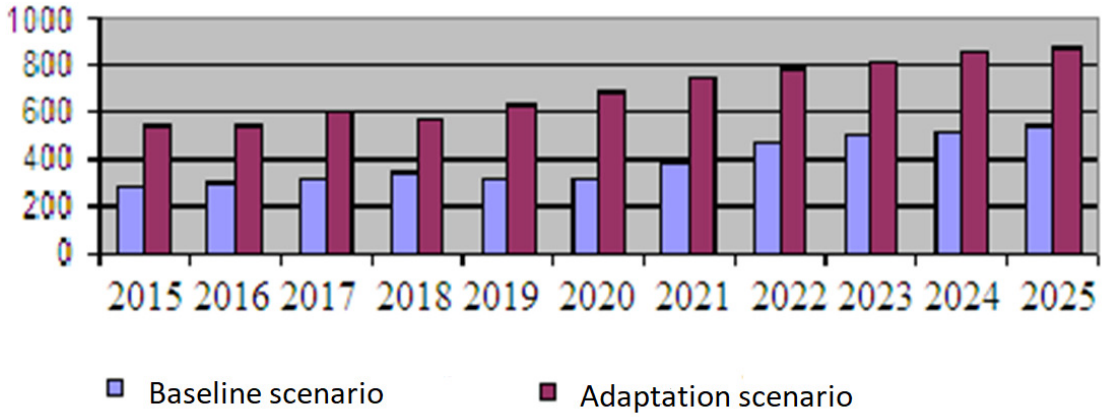
The results of the assessments prepared by the sector specialists on "Drinking water and natural sources of water supply" will provide significant input and will be used by the leaders and relevant stakeholders of ministries, departments and institutions of Uzbekistan in terms of decision-making to address climate change in the water sector.

The results of this assessment show that implementing adaptation measures will significantly reduce the adverse effects of climate change in the sector. I&FF for the adaptation scenario are **75.2-85.3**% higher than in the baseline scenario. So, if in the baseline scenario the total I&FF for the construction, repair and reconstruction of water pipelines amounted to **807.4** million soum, then in the adaptation scenario it was **1,422.5** million soum. For repair, reconstruction and construction of water supply networks, in the baseline scenario **350.0** million soum and in the adaptation scenario **634.6** million soum. For well construction, in the baseline scenario **631.8** million soum and in the adaptation scenario **1,1236** million soum. For the construction of water towers, in the baseline **683.7** million soum and in the adaptation scenario

1230.1 million soum. For the construction and repair of tanks, in the baseline scenario **623.3** million soum and in the adaptation scenario **1,092.2** million soum. For the construction, repair and reconstruction of pumping stations, in the baseline scenario **521.3** million soum and **922.5** million soum. For the construction of chlorination plants, in the baseline scenario **668.7** million soum and in the adaptation scenario **1239.6** million soum. In total for the baseline scenario, I&FF amount to **4 billion 286.2 million** soum, and for the adaptation scenario to **7 billion 665.1 million** soum. In general, the total amount of I&FF for the adaptation scenario exceeds the amount of I&FF of the baseline by **78.8**%.

The dynamics of I&FF for the baseline scenario and the adaptation scenario are shown in the figure (Figure 2). It can be seen from the figure that for the adaptation scenario the amounts of I&FF exceed the amount of I&FF of the baseline scenario.

Figure 2. Dynamics of I&FFs for the baseline scenario and the adaptation scenario (in million soum)



6. Political Implications

It should be noted that the current legislative framework in the Republic of Uzbekistan allows organizations and institutions to carry out activities in the field of drinking water supply systems and the use of natural water sources. At the same time, projected climate change can lead to a significant deterioration in the functioning of centralized drinking-water supply systems, the quality of drinking water and natural water sources. This makes it necessary to strengthen the regulatory and legal framework and improve legislative acts in the field of water resources management, to provide the population with safe drinking water and to optimize the ecological status of water bodies in the Republic of Uzbekistan.

The implementation of the adaptation scenario requires concrete actions, for example, the adoption of a law in the Republic of Uzbekistan on the transition to paid water use, the adoption of the law on the establishment of a Water User Association, the decision to issue permits for special water use to state sanitary inspectors, etc. First of all, this concerns political decisions on the following issues:

- Construction of inter-district and communal rural water pipelines;
- Use of artesian or deep-seated groundwater, which is well protected against pollution;
- Prohibition of the use of natural water sources for needs not related to drinking water supply;
- Creation of special services for the construction, operation and repair of rural water pipelines;
- Step-by-step introduction of a system of paid water use based on a differentiated tariff policy;
- Improvement of existing regulatory and legal documents in the water sector in accordance with the requirements of international standards;
- Mobilization of foreign sources for financing the construction of interregional water pipelines in rural settlements.

The existing legal basis for water management does not meet modern requirements and needs to be improved. The administrative and territorial system of water resources management leads to inconsistency of management decisions within the framework of a single river basin. There is an inconsistency in the use and protection of water resources (surface, groundwater, return water), a lack of coherence between the different levels of water management, and there is yet no mutual interest between water resources management bodies and water users to increase the productivity of water resources use. All this underscores the need for a gradual and consistent implementation of the principles of Integrated Water Resources Management in the Republic of Uzbekistan.

Experience in introducing Integrated Water Resources Management exists in

many countries, and in Uzbekistan this activity is just beginning. In the Republic, it was possible to create a scientific basis for integrated water resources management and some aspects were tested during the pilot project "Integrated Water Resource Management-Fergana". It is advisable for the national Government to review the results of this project and, if necessary, consider the possibility of implementing this mechanism throughout the country. To this end, the Government needs to take a decision to change the management structure of the water management complex.

As noted earlier, in Uzbekistan, sources of water supply are mainly of transboundary nature. Countries in the basins of transboundary rivers are united through water ecosystems. Any change in water use in one country inevitably affects the interests of other countries. The need for a modern, interrelated and coordinated system for managing transboundary water resources is caused by nature itself and requires the creation and development of a mechanism for cooperation on integrated approaches.

As it is known, a tense situation in the management of transboundary water resources in Central Asia has developed in the basins of the Amudarya and Syr Darya rivers. The countries of Central Asia have a fairly large experience of working together to solve problems of interstate water relations, the positive results of which are recognized throughout the world. On 18 February 1992, the heads of the water management departments of Central Asia signed in Almaty the "Agreement between the Central Asian states on cooperation in the joint management of the use and protection of water resources of interstate sources", which was subsequently approved by the heads of state on 26 March 1993 in Kyzylorda. By this agreement, the parties established the Interstate Water Coordination Commission with the executive bodies of the Basin Water Management Organization"Amudarya" and the Basin Water Management Organization"Syrdarya". It should be noted that the Scientific Research Center of the Interstate Water Coordination Commission is located in Uzbekistan in the building of the Scientific Research Institute of Irrigation and Water Problems. Supervised by Professor VA Dukhovny.

By recognizing the principles of international law, the countries of Central Asia and the founders of the International Fund for Saving the Aral Sea increase their ability to appeal to the UN for assistance to solve various issues, e.g. by possibly of involving international financial institutions and bilateral donors to solve regional water-related environmental problems for a sustainable development of the region.

"The Convention on the Protection and Use of Transboundary Watercourses and International Lakes" (Helsinki, 1992) entered into force on 6 October 1996. It determines that "Transboundary waters are any surface or groundwater that indicates, crosses or is located on the borders between two or more States; where transboundary waters flow directly into the sea, their end is determined in a straight line across the mouth of the rivers between the points of the horizon of the shallow waters of their shores."

The proposal on the accession of all the countries of Central Asia to the above Convention was considered at the Interstate Water Coordination Commission meeting in Almaty, 14-15 June 2002, and a protocol note was made to "Members of the Interstate Water Coordination Commission" to consider making proposals to their governments in due course on the possibility of ratifying the "Convention on the Protection and Use of Transboundary Watercourses and International Lakes (Helsinki, 1992)".

The will of Central Asian countries to cooperate to solve the most acute problems of the region was clearly expressed during the development of the Aral Sea Basin Programme.

The program consists of four priority areas to:

- stabilize the ecological situation in the Aral Sea basin;
- restore the crisis zone around the Aral Sea;
- improve the management of international waters in the Aral Sea basin;
- strengthen the capacity of regional bodies to plan and implement the Aral Sea Basin Programme.

The solution of this problem led to the creation of special institutions in the form of the International Fund for Saving the Aral Sea, which includes: their Board, an Interstate Commission for Water Coordination, an Interstate Commission for Sustainable Development and a Scientific Information Center. The activities of the International Fund for Saving the Aral, which is financed by the Central Asian states, were significantly reinforced by external financial assistance through projects of the United Nations Development Program and the Global Environment Facility (GEF).

In addition, each of the Central Asian countries adopted a National Environmental Action Plan.

One of the determining factors of the implementation effectiveness of environmental policy are:

- management and regulation of environmental issues;
- perfection of legislation in the field of environmental protection;
- effectiveness of economic methods and mechanisms for environmental management.

Most important for the countries of the Central Asian region is that the presidents and governments of all five countries support and implement policies that ensure environmental security. In all countries, the National Environmental Action Programs have been developed, the main laws implementing environmental policy have been put in place and are functioning successfully, the economic mechanisms for environmental management are basically similar.

The cooperation of Central Asian countries in the framework of regional programs and institutes allowed to develop certain methods, and cooperation

style between countries on managing and using transboundary water resources. These approaches are unique in their own way, as coordination, action planning, adjustment and distribution of water resources on an ongoing basis are carried out within the framework of this cooperation.

However, as the water expert collaboration and the I&FF assessment show, there is a certain inertia and stagnation in the activities of regional and intergovernmental organizations, in particular regarging the improvement of regional water policy and the strengthening of the legislative base. For an effective management of transboundary river basins, a new system of national and regional norms and rules for the use and protection of water resources is required, with clear procedures and economic mechanisms.

7. Uncertainties and Methodological Limitations

1. The main uncertainty is the absence of an officially approved government program for the development of drinking water supply systems in Uzbekistan until 2025, which serves as the basis for the baseline scenario and for the "historical" period (2006-2014).

2. Among the uncertainties, certain specific indicators can be included that were used in the calculations. In the future, until 2025, some of them may change, such as the construction of new facilities and regional water pipes in the countryside for example; and this would implicate a change in associated I&FF required.

3. The absence of representative indicators for financial flows for certain periods has made it necessary to determine them based on the extrapolation of data and expert assessments. This means that this indicator may change, implying either an increase or decrease of associated I&FF.

4. Calculations of the adaptation scenario were carried out focusing on national sources, not including potential investments from foreign financial organizations, due to the lack of dynamic data for investments during the assessment period.

5. There are significant uncertainties about climate change. There are no exact calculations on climate change dynamics for target territory during the assessment period.

6. There are still unresolved water issues and inconsistency in the distribution of transboundary water resources at the interstate level in the countries of Central Asia.

Overarching Conclusions

The I&FF assessment of the **electricity sector** to implement measures to reduce greenhouse gas emissions allow to draw the following conclusions:

1. Despite the measures taken in recent years to upgrade the fuel and energy complex, the energy system of Uzbekistan remains vulnerable to energy security.

2. Currently, in the context of growing global climate change impacts, Uzbekistan does not yet actively pursue the diversification of the energy generation structure through introducing renewable energy sources (solar, wind, etc.).

3. A set of measures to mitigate climate change is foreseen, along with the implementation of major investment projects for the expansion, modernization and construction of new thermal generating facilities. These measures include:

- The expansion of the hydropower potential through constructing 42 new and upgrading 32 operating hydroelectric power stations on natural watercourses and water management facilities of the Republic;
- The implementation of advanced demonstration projects of new photovoltaic and wind power plants, which ensure a high efficiency of power generation.

4. An analysis of the mitigation scenario for the development of the electricity sector shows that the implementation of the action plan will help limit the negative consequences of climate change in the country. At the same time, the sustainable operation of the electricity sector will ensure:

- Meeting the country's electricity needs resulting from an increasing demand from enterprises and the population, and taking into account the projected GDP growth of 1.5-2 times by 2025;
- Diversifying the structure of generating capacities by increasing the share of renewable energy sources to 2.5%, which is equivalent to the release of natural gas for the whole assessment period in the volume of 1.32 billion m^3;
- Reducing greenhouse gas emissions compared to the baseline scenario by 2.4 million tons of CO_2.

5. Compared to the baseline scenario, the implementation of the mitigation scenario will require total I&FF of US$ 26.9 billion, including investment flows of US$ 12.2 billion, financial flows of US$ 1.2 billion and operation and maintenance costs of US$ 13.5 billion. At the same time, the total I&FF of alternative types of electricity will be US$ 854.9 million.

6. Implementing a set of mitigation measures for renewable energy sources will ensure:

- Creating conditions for sustainably providing regions with energy through the introduction of renewable energy sources;
- Reducing the mono-dependence of the energy sector from natural gas, and thereby improving the country's energy security;
- Creating a qualitatively new field of energy in the country - using renewable energy sources with a qualitative new technological solution that promotes the development of high-tech industries, as an alternative to the conventional energy based on hydrocarbons;
- Actively socially and economically developing remote areas through guaranteed energy supply to business entities and the social sector;
- Substituting hydrocarbons and restricting the emission of greenhouse gases into the atmosphere;
- Raising the technical level of specialists in the regions regarding the construction and operation of renewable energy sources.

7. The I&FF assessment results can be used for the implementation of the set of measures and corresponding roadmaps, and mitigation projects in the energy sector by: policy-makers and relevant specialists of the joint-stock companies Uzhydromet, "Uzbekenergo" and "Uzbekhydroenergo", the Ministry of Economy and other key line Ministries, departments and institutions of the Republic of Uzbekistan.

8. According to the Intended Nationally Determined Contribution (INDC) for the period up to 2030, Uzbekistan aims to reduce specific greenhouse gas emissions per unit of GDP by 10% by 2030 compared to the level of 2010 through the implementation of:

- Programmes to reduce energy intensity of economic production, to introduce energy-saving technologies in the economic, social and renewable energy sectors **(as reflected in the I&FF assessment);**
- National development concepts and reports (National Communications etc.) **(as included in the I&FF assessment);**
- A set of measures on energy efficiency in the economic and social sectors **(the I&FF assessment envisages the implementation of a set of measures to mitigate climate change, resulting in a fuel consumption reduction from 359.8 g/kWh in 2017 to 283.5 g/kWh by 2025, with a total reduction of greenhouse gas emissions by 11.16 million tonnes of CO_2)**.

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The main results and conclusions of the I&FF assessment in the **agriculture sector**, based on the above analysis, are as follows:

1. It is important to improve the legislative and regulatory framework in the field of administrative responsibility and to better enforce existing regulations

regarding the mismanagement of lands, violation of the state land cadastre, leading to a decrease in soil fertility and soil degradation.

2. It is necessary to introduce changes and additions to the relevant legislative acts to further improve farming activities, to effectively use agricultural areas, including determining the legal status of multi-sector farms.

3. A main point to address is the creation of financial mechanisms promoting the introduction of renewable energy sources, and the creation of favorable conditions for attracting investments, especially foreign direct investment.

4. Support is needed for the implementation of investment projects on the use of resource-saving technologies, and for the production of technological equipment for drip irrigation.

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Finally, the I&FF assessment of the **social sector** focusing on **"Drinking water and natural sources of water supply"** showed that:

1. By 2025 the runoff of natural water supply sources will decrease by an average of 15-20%. The total reduction in river flow will be about 3400 million m^3.

2. Due to the projected increase in temperatures of 1-2°C in Uzbekistan, the quality of drinking water is expected to decrease by 30%, the mineralization of water supply is expected to increase by 25%, while 25% of water supply systems are expected not to meet the requirements of sanitary standards, 40% of water supply networks are expected not to meet the requirements, and 25% of the substance and technical equipment of water pipes is expected to deteriorate.

3. Measures assessed within the sector "Drinking water and natural sources of water supply" include: Construction and repair of water pipes, water supply networks, wells, water towers, tanks, pumping stations, and chlorination plants.

4. It was calculated that the total amount of I&FF for the historical period in the drinking water sector was 499.4 million soum. Out of this, the percentage of I&FF for the construction of water pipelines was 18.5%, for water supply networks was 8.2%, for wells was 14.5%, for water towers was 19%, for tanks was 12%, for pumping stations was 10.2%, and for chlorination plants was 17.6%.

5. The conducted assessment showed that for the baseline scenario the amount of I&FF drinking water sector is **4,286.2 billion soum, and for the adaptation scenario is 7,665.1 billion soum.**

6. It was determined that the I&FF for the adaptation scenario **are higher** compared to the I&FF of the baseline scenario: by 75.2% for the water pipes;

by 81.3% for water supply networks; by 77.8% for wells; by 79.9% for water towers; by 75.2% for tanks; by 76.9% for pumping stations; and by 85.3% for chlorination plants.

7. Calculations showed that the implementation of the planned adaptation scenario in the Republic of Uzbekistan by 2025 **will allow**: to reduce the levels of anthropogenic pollution of natural water sources, to provide the population with safe drinking water, to modernize the systems of centralized drinking water supply, to reduce the cost of fresh water for irrigation of crops, and to use water resources that are not fit for non-drinking purposes for agriculture.

8. The I&FF assessment for the period up to 2025 will be useful for the Ministry of Municipal and Consumer Services, the Ministry of Agriculture and Water Resources, the Committee for Environmental Protection, design institutes, the Irrigation and Water Problems Research Institute, the Republican Center for State Sanitary and Epidemiological Surveillance, to implement measures to protect water bodies and drinking water.