The impact of climate change on the water resources of the Panj river basin of the Republic of Tajikistan

«*A fundamental solution to the problem of water scarcity and overcoming the risks associated with climate change and natural disasters is seen in the development of hydropower with integrated reservoirs, with the cooperation of stakeholders ".* ***Emomali Rahmon, President of the Republic of Tajikistan».***

Annotation

Tajikistan is considered the most vulnerable, Central Asian country, to the adverse effects of climate change. Key territories, such as the Panj River Basin, are already experiencing repeated losses caused by natural disasters, including flooding, landslides, and drought. Recent droughts and extreme weather have clarified the existing inadequacy in most sectors: for example, the inability of irrigation infrastructure to support agricultural production due to water loss, poor irrigation efficiency, flooding, salinization of the soil, and reduced productivity. Climatic events show that in Tajikistan the temperature will rise to 2 degrees Celsius by 2050 and average precipitation will decrease. An increase in temperature will lead to accelerated melting of glaciers, with the probable disappearance of 30% of the mass of glacial systems by 2050.

Key words: impacts of climate change, the Panj River Basin, natural disasters, flooding, landslides, droughts, glaciers, glacial lakes, irrigation infrastructure, precipitation, climate disasters, water scarcity.

On the territory of Tajikistan there are more than 10 thousand large and small glaciers, the volume of which is more than 850 cubic kilometers. The largest and most located on land is the Fedchenko Glacier, whose length is 76 kilometers and a total volume of 144 cubic kilometers. Fedchenko Glacier is a regulator of the Vakhsh River and an indicator of the climatic state of Central Asia. The total area of all glaciers in the country is 6 percent of the total area of the republic. Over the past 40-50 years, more than thousands of glaciers of the republic have melted under the influence of climate warming, some small glaciers have completely disappeared. With an increase in average air temperature from 1.8 to 2.5 degrees by 2050, the trend of melting glaciers will continue, and the number of glaciers will be reduced by half.

It should be noted that a significant part of the Central Asian water resources is concentrated precisely on the glaciers of Tajikistan. Thus, the melting and disappearance of glaciers in the country represents a huge threat to the entire region as a whole.

The maximum seasonal runoff is likely to carry over from early spring to late winter. As a result of these changes, significant consequences are expected for the availability of water for human consumption, irrigation, and hydropower production. In particular, an increase in temperature will lead to an increase in evaporation and an increase in water deficiency in the summer. The adverse effects of climate change will be acutely felt by a part of the population that is already vulnerable by gender, age, (or disability), 75% of the poor

live in rural areas. It is assumed that climatic disasters are capable of overturning a large percentage of the population into extreme poverty. Climate change is likely to unite existing food security issues and greatly affect those that are dependent on agriculture. Women and children, who constitute the largest population of the country, are vulnerable to the effects of climate change in Tajikistan. They often have the responsibility of ensuring the safety of water, food, fuel for cooking, and heating the premises in rural Tajikistan. Thus, for subsistence they are dependent on natural resources that are threatened by climate change.

The Panj River has an international border between Afghanistan and Tajikistan. The area of the river basin is about 107,000 square kilometers (of which 40% is in Afghanistan and 60% in Tajikistan) in the mountains, extending along the lower floodplain with an area of about 6,500 square kilometers. The length of the Panj River is about 1000 km before its transformation into the Amu Darya River after its confluence with the Vakhsh River. The Bartang, Gunt and Vanj rivers (a basin of 2070 km2 and a length of 92 km), Yazgul and Kyzylsu are one of the largest right tributaries of the Panj river, as well as the Chordara, Khumbob and Yakhsu rivers are connected to the Panj river.

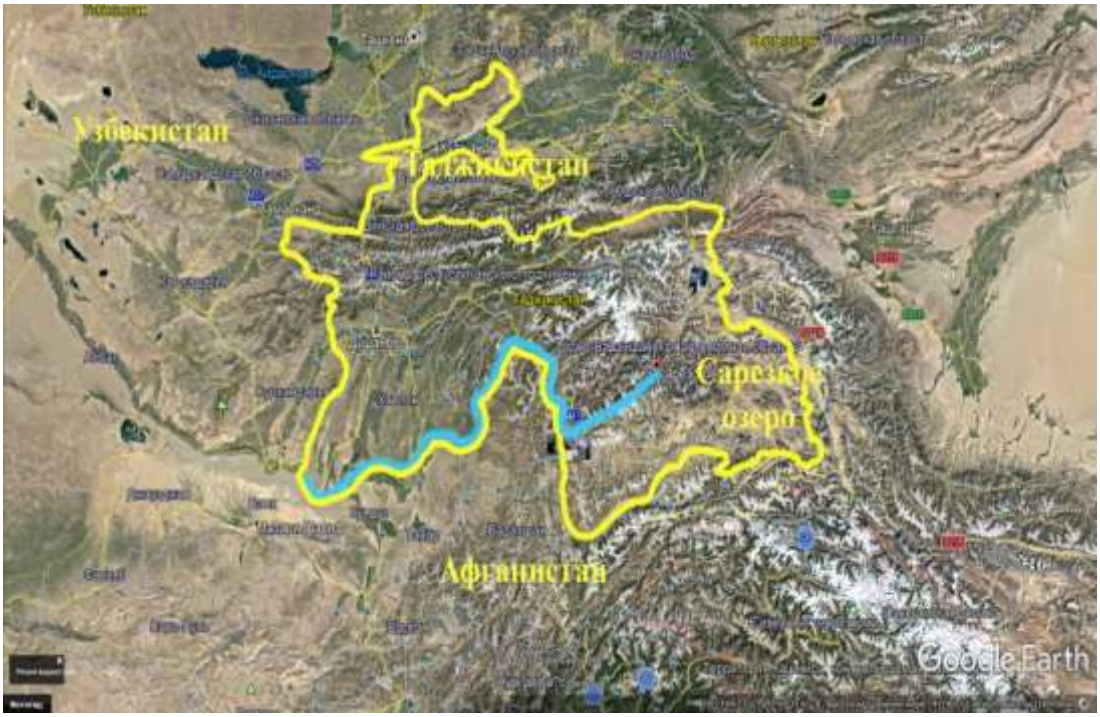

Fig. 1. Sarez Lake and tributaries of the Panj River Basin.

The area of the Yazgulom river basin is 1970 km2, and the length is 80 km. The length of the Bartang River is 558 km, the basin area is 24,700 km2, the Gunt River is 296 km, and the basin area is 13,700 km2. This is the largest tributary of the Panj River in terms of both the basin area and its length. According to the current trend, the largest right tributary of the Panj River is the Kyzylsu River, whose length is 230 km and an area of 8630 km^2. From this basin the zone of Kulob district and Panj district will be provided with irrigation water.

The collector-drainage network of the Kyzylsu river basin (Mir Said Ali Hamadoni, Farhor and Kulob districts) is mainly located at the river level and consists of the volume of fresh water discharged from the Panj, Kyzylsu, Yakhsu rivers, which are almost equal to the

source of water taken. The Kafirnigan River also divides the Kabodiyon Valley from north to south and flows into the Panj River.

Table 1.

TAKED WATERS OF DISTRICTS AND CITIES FROM NATURAL SOURCES FOR 2019

Name of the basin and rivers	Name of cities and areas from irrigation systems	The volume of water, million m3	Irrigated lands, ha
Panj River	r. Panj	282,6	15061
Panj River	r. Hamadoni	136	16430
	r. Farkhor	252,4	24632
r. Panj r. Bartang r. Gunt r. Humbov r. Shohdara	r. Darvoz	12,1	993
	r. Vakhsh	24,5	2577
	r. Rushon	25,4	2024
	r. Shughnon	14,2	3525
	r. Ishkoshim	32,6	4472
	r. Khorugh	6,4	297
	r. Murghob	3	2036
	r. Roshtkala	20	2846

The Panj River has a large amount of sediment, and it is estimated that about 750,000 m 3 of deposited sediment flows into the Chubek irrigation system every year, which is a huge burden on the budget for the operation and maintenance of cleaning the irrigation network. Bottom sediment is diverted back to the Panj River at the Chubek Main channel Regulator through the drain channel with a threshold level of 60 cm. Since sediment concentration is associated with a spillway, about 84% of sediment enters the Chubek irrigation system during the three months of summer June, July, August. Fortunately, hydrology and existing infrastructure facilities contribute to the construction of an effective and reliable sediment - discharge basin, which could be located at the beginning of the section of the Main Channel Chubek.

The poor state of flow and sediment registration seriously affects factors such as:

• Firstly, inadequate irrigation systems are evident from the general situation in agricultural production, indicating a low level of cultivated areas, low yield and lower than the total size of agricultural products. Water consumption for yield for future cropping systems and intensities should be based on agroclimatic factors, not historical records.

• Second, irrigation efficiency is an important parameter for calculating future irrigation needs. In the course of the research, attempts were made to assess the effectiveness of irrigation using remote measurement data. Although this method provides fairly reliable estimates of the total water consumption, actual flow data are required to measure the level of

efficiency, and the reliability of the measured level of irrigation feasibility will not be better than hydrological observations.

• Thirdly, the current situation of these flows and sediments emphasizes the need for a strong and well-equipped institutional mechanism with trained personnel for regular observations, analysis and recording of observational data. Sufficient resources must be allocated for the acquisition of appropriate field equipment to monitor water flow and take sediment samples in the basin, establish laboratories to analyze sediment samples, and train the appropriate staff.

Agricultural resources.

During the Soviet Union there was no shortage of high-quality seeds, pesticide fertilizers. Currently, there is an acute shortage for all three, prices are high and quality is low. Wheat seeds can contain up to 20-30% of impurities; therefore, the quality of the seeds must be very high. Available varieties vary from year to year and may not be appropriate for the region. Seeds do not come with an official certificate and etiquette. Although there are several control systems and seed supply units at the Ministry of Agriculture, the system clearly cannot handle the supply of appropriate seeds for farmers. Two fertilizer plants were closed during the Soviet Union and all fertilizers were imported, there are many complaints about the cost and quality of imported fertilizers. Few farmers are available to pay for fertilizer or equipment.

The staff of each jamoat has an agronomist. Although this is good, agronomists need training and support along with resources to provide advice / services to farmers.

Water requirement.

Different crops require different amounts of water depending on the time of sowing and harvesting, and the water requirement for winter vegetables is much lower, about 1/3 of summer vegetables. The following are measures to improve farm management and water use efficiency in the Pyanj River Basin in order to increase agricultural productivity and farm incomes, and thereby reduce poverty, and this:

- Through demonstration plots, disseminate a wide range of agronomic practices, agricultural technologies and farm water management practices to promote the efficient use of water and higher water productivity;
- Introduction and multiplication on local farms of high quality seeds of improved varieties of wheat, cotton, vegetables and other important crops;
- Developing the institutional capacity to expand the staff of district agriculture so that they can transfer and continue to advise farmers on agricultural technologies and fulfill irrigation supply and responsibilities in effective ways.
- Facilitating the reorganization / creation of water user associations (WUAs) at the hydrological borders and developing the potential of WUAs, as well as beneficiaries in water management and their official business. Improving the skills of the beneficiaries and encouraging the creation of a value chain and increasing value added.

Figure 2. Border crossing points on the Panj River.

In Tajikistan, an effective system of managing measures for the prevention, elimination, previously on raising, assessing the danger and risk of natural disasters has been established. The most vulnerable areas of the territory where educational and methodological gatherings, trainings, trainings and exercises are held to increase public awareness of possible emergencies or natural disasters are identified. Special programs have been developed for the training and education of secondary school students, university students, senior personnel, as well as workers, employees and the population of the republic on the basics of natural disasters and emergencies.

There is multilateral and bilateral international agreement on cooperation with regional, global and international organizations in the field of disaster risk reduction.

Considering that 40% of the Panj River Basin covers the territory of Afghanistan, and serious flooding has often occurred in this regard, in 2010 both states signed a bilateral agreement for joint hydrological monitoring of the Panj River with the support of development partners, including ADB. The subjects of cooperation include coordination and assistance in the installation and modernization of weather stations on the Panj River, the conduct of mutual expeditions, training, exchanges of experience, as well as the organization of meetings, scientific seminars, and round tables. The parties also developed an action plan to create a joint Panj River Basin Commission. To date, both states are trying to find technical and financial support for the implementation of the action plan.

Figure 3. The meeting between the heads of the Department of Natural Disasters of the Republic of Tajikistan and the Islamic Republic of Afghanistan in 2018, the city of Dushanbe.

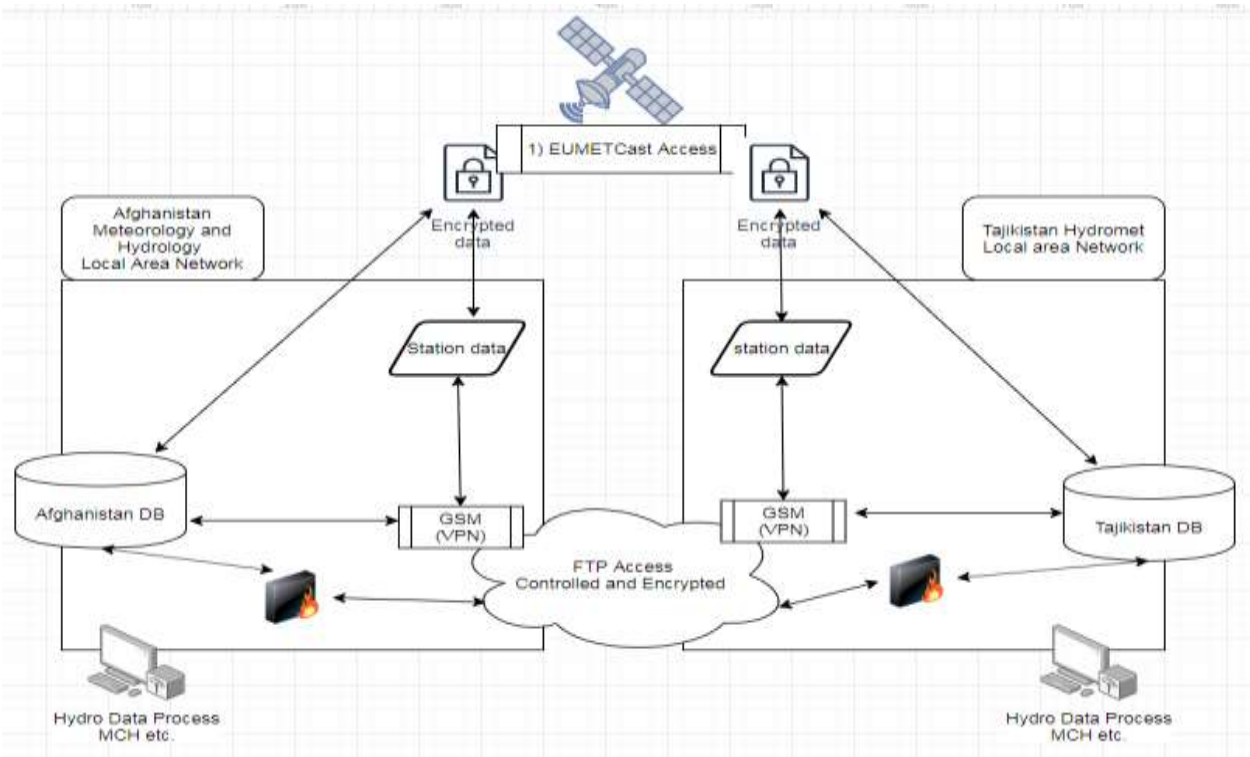

Figure 4. Scheme of preliminary hydrometeorological studies of Tajikistan and Afghanistan compiled on the basis of a bilateral memorandum of cooperation.

It should be noted that over the past 15 years in neighboring Afghanistan in 23 districts, 4 northern regions of Balkh, Chavzon, Tahor and Kunduz more than 14 685 hectares of arable land were washed by river movement of the Panj River.

Figure 5. The impact of the Panj River displacement on arable land in the Tahor province of the Islamic Republic of Afghanistan.

Figure 6. Moving the Panj River in the Karkin region of the Islamic Republic of Afghanistan.

Natural disasters.

In recent years, the number of natural disasters in the Republic of Tajikistan has increased many times, which has affected the nature, socio-economic situation of the republic

and the well-being of the country's inhabitants. Long-term observation of temperature indicates that in recent years, the average annual air temperature in the Republic of Tajikistan has increased by one degree Celsius, as well as the frequency and intensity of natural-hydrometeorological phenomena.

For the country's agricultural sector, which employs more than 60% of the population, such disasters are particularly devastating. About 75% of women and 42% of men in the country are employed in the agricultural sector, and more than 1 million people are constantly in food shortages and are subject to repeated climate shocks.

The high temperatures of recent years have caused massive glacial floods and mudflows, which led to the erosion of vital infrastructures, crops, transport networks, electrical networks, shore protection dams and hydraulic structures, which require restoration for several months or years and high financial costs. The occurrence of natural disasters due to climate change in addition to high seismic activity threatens to nullify a significant part of the results of Tajikistan's progress over the past few decades. Over the past 25 years, a series of major natural disasters has been observed throughout the country, resulting in economic losses of more than $ 2.1 billion, affecting more than 80% of the country's population and mainly affecting the most vulnerable segments of the population.

Each year, the Government of the Republic of Tajikistan directs multimillion-dollar budget and extra-budgetary funds to the prevention and elimination of natural disasters. Some of these funds are allocated for the resettlement of the affected population and the provision of material assistance to them. Another part is used to restore the affected infrastructure, construction and restoration of shore protection dams. In addition, a program for adaptation to climate change was developed, the purpose of which is to improve the adaptation monitoring system and early warning system, as well as research work has been carried out.

Global climate change has a direct impact on the activation of the natural processes of our country. The increase in temperature led to droughts, natural disasters partially manifested, and the area of glaciers from which the main rivers supplying our country and the Central Asian region decreased. Further warming could jeopardize the entire energy industry and agriculture of this Republic of Tajikistan. In this regard, the Government is developing urgent measures to adapt to climate change. The solution of these problems requires the joint efforts of the Central Asian states, authorities, NGOs and citizens of this region.

Water and agriculture in the republic can be significantly affected by climate change. It is known that crops require more water, especially for irrigation, taking into account the evapotranspiration of plants. The irrigation norms of the main crops will also increase, land degradation will occur, and there will be risks of the development of desertification processes in the southern and central regions of the republic.

General forecast:

By 2050, several thousand small glaciers will completely disappear in Tajikistan. Degradation of glaciation will most strongly affect the flow of the Zarafshon, Kafirnigan rivers and tributaries, and Obihingou. The country's glaciation area will decrease by 20%, ice volume will decrease by 25%, however, the largest, most important glaciers will remain, although they will become somewhat shorter and their tongues will be located higher. The Panj glacier runoff will hardly change; the flow of the Vakhsh river will decrease somewhat due to a decrease in the runoff of the Obihingou River.

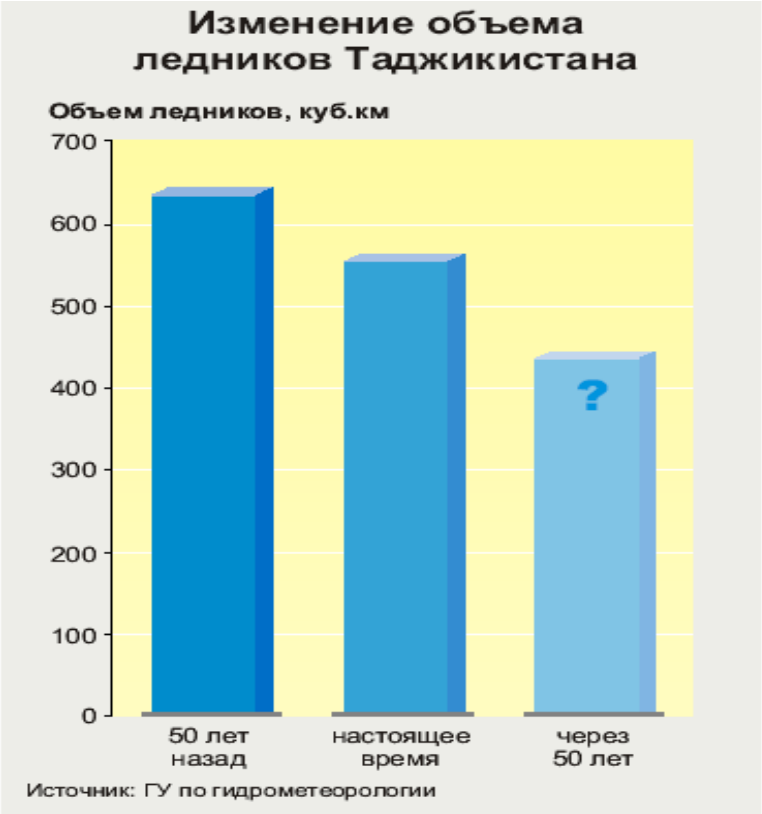

Fig 7. Changes in the volume of glaciers in Tajikistan.

The area of glaciation of the country may decrease compared to the present time by 15-20%, and the water reserves in glaciers by 80-100 cubic km. But large glaciers and glaciation sites will remain. Glacial runoff r. Panj, Vakhsh, and the Amu Darya as a whole, due to the active melting of glacial reserves, may increase in the beginning, however, in the long run, on the contrary, it will decrease due to depletion of ice reserves. An adverse change in the hydrological regime of rivers can have serious consequences, both for individual vulnerable communities and the entire region.

It is gratifying that in Tajikistan fundamental research has begun in the field of studying the state of glaciers, in glaciology and the cryosphere. On behalf of the President of the Republic of Tajikistan in 2018, the State Scientific Institution “Center for the Study of Glaciers of the National Academy of Sciences of the Republic of Tajikistan” was established. The Center is currently conducting expeditions, improving scientific discoveries in the field of cryosphere and glaciology, as well as fixing the state of glaciers, which will allow us to find out the exact number and condition of existing glaciers of the Republic of Tajikistan in the near future. And also in the republic, new scientific and fundamental research in the field of cryosphere and glaciology was revived, which will allow the Center’s employees to start preparing the “Glacier Atlas of Tajikistan”. Based on the above achievements, Tajikistan is included in the Unified Global Glacier Monitoring System, and the Center is a member of the World Meteorological Organization for Cryosphere and Hydrology.

The Center, together with its Swiss colleagues, organized a joint expedition to the Zulmart and Yakarcha glaciers, the tributary of which is the Panj River, where an automatic weather station was installed. The weather station is connected to sensors and can record and store glacier data for a year. One of the significant results of the Center is the use of unmanned aerial vehicles for the study of glaciers with a resolution of 5 to 7 centimeters.

Comparison of satellite data and the received drone information will allow us to accurately determine the location of the glacier on the map. In addition, research on glaciers is carried out using GPS, GIS, Arc GIS, Qu GIS, Sanitel LandSAT.

Tajikistan is one of the most vulnerable countries in Central Asia, and climate change poses a serious threat to the entire region. Therefore, it is necessary to actively consolidate collective efforts in the field of adaptation to climate change and emergency situations at the regional level.

Conclusion:

Comparison of retrospective average annual flow rates of the main rivers in the Panj basin with future indicators according to forecasts of hydroclimatic models suggests that a gradual increase in the annual flow of the Panj River is expected by 2100. In particular, these risks will manifest themselves in the form of: increased water demand, especially for irrigation, due to an increase in air temperature and total evaporation, which will lead to a shortage of water. This could happen by the end of this century and will affect agriculture, livelihoods and ecosystems. There may be periods of extreme heat or cold affecting human and livestock health, as well as agricultural production. Damage to life and property, agriculture, livelihoods and ecosystems will increase due to more frequent mudflows (sudden avalanches, flows carrying sedimentary material caused by heavy rainfall and snowmelt, especially in the spring season), and also due to annual flooding of meltwaters of rivers with glacial nutrition. According to researchers, the main climate changes will be as follows:

• The air temperature in the Pyanj river basin will increase by about 1.7 ° C in the period from 2010 to 2050, and by 3.5 ° C in the period from 2050 to 2100;

• The average annual total evaporation will increase as a result of rising air temperatures;

• Significant changes in the chronological profile of average monthly rainfall and snowfall can also be expected;

• There may be gradual changes in the seasonal distribution of river runoff, with higher runoff closer to the beginning of the year as a result of earlier melting of snow and ice caused by rising air temperatures;

• Magnitude and frequency of mudflows and floods are likely to increase.

Prospects for the regulation of glaciers.

Continental prospects, climate warming and the resulting degradation of glaciation are global processes that cover the entire planet, all continents of the Earth. In half a century, the glaciation of Uzbekistan will disappear, after a half century, according to the estimates of glaciologists in Kyrgyzstan, all the small and medium glaciers of the Tien Shan will melt. And mankind is not yet able to fight this phenomenon. Instead of fighting, it is necessary to adapt to a changing environment, when at the same time there is an increase in average air temperature and a decrease in glaciation. Glacier specialists offer mountain glacier management activities. However, a detailed examination reveals that almost all of them are unsuitable for the conditions of Tajikistan:

• Artificial increase in precipitation is still under development. At the height of summer, at high temperature and low humidity, it is practically impossible to cause precipitation artificially in Central Asia.

• Artificial dumping of avalanches is used in our time only on some roads and mines, but it is impossible to use it in all mountainous regions of Tajikistan. With a decrease in the amount of precipitation in the form, the number of avalanches will decrease.

Thus, almost all of the listed measures to regulate the melting of ice are not suitable for the conditions of Tajikistan. The only exception is the "accumulation of autumn runoff in the buffer tank", that is, the creation of reservoirs in the mountains. They must accumulate melt water during the offseason when it is not required for the fields. It is desirable that the surface of the reservoir is as small as possible, and the depth as large as possible: this reduces evaporation losses. At the same time, reservoirs should be safe, in case of a breakthrough (landslides, landslides, mudflows, destruction of dams by an earthquake), the damage should be minimal. Such dams can be created by the method of explosion or build capital, made of reinforced concrete, with emergency discharge, in case of overflow. Reservoirs without hydroelectric power stations, intended only for irrigation, already exist in our republic: Selbur, Muminobod, but they are located in the valleys.

The second way to deal with low water caused by degradation of glaciation is the construction of pumping stations that supply water from large rivers to terraces and slopes.

And, of course, one of the main is water-saving, economical irrigation: closed aqueducts, dukers, irrigation ditches, replacing all of our agricultural technologies with more modern ones, used in the countries of the Near and Middle East with a hot arid climate and low rainfall.

Literature:

1. “Water Cadastre of the Republic of Tajikistan”, publication of the State Institution “TajikNIIIGiM”, Dushanbe, p. 8. 2020.
2. Main report TA 8647-TAJ: “Water Resources Management in the Panj River Basin” source Ministry of Energy and Water Resources of the Republic of Tajikistan Dushanbe, November 2015.
3. Report on the “Panj River Migration - Amu River from 2000 - 2019” National Statistics and Information Center of the Islamic Republic of Afghanistan NSIA, Shuob Saburi 2019, Afghanistan.
4. “In Tajikistan, fundamental research has begun to study the state of glaciers” Materials of the State Scientific Institution “Center for the Study of Glaciers of the National Academy of Sciences of the Republic of Tajikistan”, 2019, Dushanbe.