Impact Assessment of climate change on water resources of the Amu Darya River basin

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Abstract. Water consumption and water use have been continuously increasing, and the impact of economic activities on the hydrological regime of water flow, especially in irrigation, population and industry, has increased significantly. In particular, it is significantly increasing in the countries of Central Asia, including the Republic of Uzbekistan. Today's global problem is the severity, scale and unusualness of anthropogenic climate change, especially in developing countries, creates the need for action with an urgent scientific approach. Undoubtedly, the assessment of the observed climate change and the current state of water resources will require many years of in-depth scientific research. One of the factors limiting the development of the countries of the Amu Darya basin is the lack of water resources. The world is experiencing intensive climate warming, which leads to the melting of glaciers, which are the main sources of fresh water for the river basins that make up the water resources of the countries of Central Asia. The article gives an assessment of regional and local climate change and gives recommendations for reducing water shortages in the countries of the province Keywords: water resources, formation, climate change, temperature, Amu Darya River Basin

1 Introduction

As a result of the rapid growth of productive forces at the end of the 20th and the beginning of the 21st century, the rapid use of natural resources, the development of agriculture and the development of new lands, the ecological balance and ecological tension was disturbed [1, 2].

Water is one of the important components of the environment, ensuring the well-being of the population, the existence of flora and fauna, a renewable, but at the same time a limited natural resource [3, 4].

In the past few decades, water consumption and water use have been continuously increasing, and the impact of economic activities on the hydrological regime of water flow, especially in irrigation, population and industry, has increased significantly. In particular, it is significantly increasing in the countries of Central Asia, including the Republic of Uzbekistan [5, 6].

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The distribution of surface waters across the territory of Uzbekistan is extremely uneven. There are 17,777 natural water sources in the republic, 600 of which belong to the Aral Sea basin. The main area of stream formation is the mountainous part of the country. The main rivers of Uzbekistan, the Syr Darya and Amu Darya, originate in the highlands of Kyrgyzstan and Tajikistan. Their tributaries and components are Norin, Karadarya, Sokh, Chirchik. The Zeravshan and the Surkhandarya Rivers also flow through the republic. There are 505 lakes in the republic, most of them are shallow reservoirs with a water surface area of less than 1 km^2 , and in the upper reaches of the Pskem, Surkhandarya and Kashkadarya rivers there are mountain glaciers (small formations) used water flow generated outside of Uzbekistan - 57.8 km^3. Explored groundwater reserves are 7.8 km^3 [7, 8].

The main tributaries of the Amu Darya River, the largest in terms of catchment area and discharge in the Aral Sea basin, are the Pyanj, Vakhsh, Kafirnigon and Surkhandarya, with 76% of its flow originating in Tajikistan. The annual volume of water in the Amu Darya River ranges from 55 to 110 km 3 , and averages 77 km^3 [2]. Uzbekistan receives 42.2%, Turkmenistan 42.3%, Tajikistan 15.2% and Kyrgyzstan 0.3% of water from the Amu Darya [9, 10].

The catchment area of the Amu Darya is 227,000 km^2, the flow volume is 78 km^3/year, and the length is 1440 km. formed [4] as a result of climate change, the amount of water resources and the process of their formation change from year to year. Over the past 30 years, the Himalayan glaciers have shrunk and thinned, and in the next decade, their melting accelerated. For example, Himalayan glaciers are shrinking by an average of 30–40 m per year [5]. In Central Asia, the rate of glacier melting has increased, the glaciers of the Northern Tien Shan (Kazakhstan) have decreased by 2 km^2 (0.7% of the total ice mass) since 1955, and the Tuyuksu glacier has decreased by almost one kilometer per year since 1923 [6]. Since 1977, the glaciers of the Ak-Shirak Range (Kyrgyzstan) have lost 23% of their area (Northern Tien Shan 29% in 1955-1990 and Pamir 16% in 1957-1980) [7].

Today's global problem is the severity, scale and unusualness of anthropogenic climate change, especially in developing countries, creates the need for action with an urgent scientific approach. Undoubtedly, the assessment of the observed climate change and the current state of water resources will require many years of in-depth scientific research.

2 Materials and Methods

Considering all the above, the purposes of the study are: as a result of studies carried out within the framework of the state grant on the topic “Regulations for the regulation of flow and the development of river basins in river basins under the conditions of anthropogenic impact” and an assessment of the current state of water resources was carried out in the Amu Darya basin against the backdrop of climate change and determine the trend of the process.

In order to analyze the climate dynamics of the Amu Darya basin in the 21st century, the article uses long-term data (air temperature, precipitation) from the database of the Information Portal on Climate Change [8] and systematic analysis, comparative analysis, methods of grouping and summarizing river runoff.

3 Results and Discussion

Analysis of the data shows that since 1901, temperature and precipitation data have been analysed in an oscillatory manner. Figure 1 shows the average annual temperature of the area for the period from 1901 to 2021. It can be seen that the temperature in the Amu Darya basin increases from year to year.

The maximum value of warming in the first quarter of the 20th century coincided with 1915 and 1941, while a slight decrease in temperature was observed, but since 1977 a new increase is clearly visible.

Thus, in the period from 1901 to 2021, complex fluctuations with different periods are observed in the general characteristics of the increase in air temperature in the Amu Darya basin. That is, it can be divided into two periods 1901-70 and 1971-21 and trace its fluctuations in separate decades and other periods of time.

It can be seen from the linear trend of the average temperatures of the warm and cold periods of the year (Figure 1) that the magnitude of the trend warming obtained from 120-year data is about 0.5-1.9 °C and the air temperature increased by 2 °C

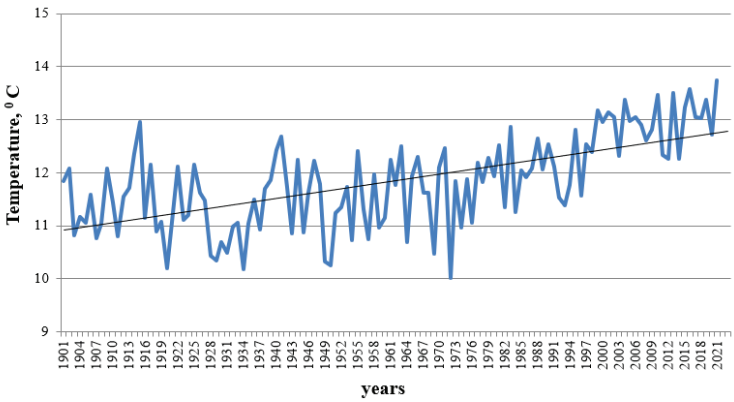

Fig. 1. Changes in mean annual air temperature in the Amu Darya basin from 1901 to 2021.

The change in the average annual air temperature in the countries of the Amu Darya basin from 1901 to 2021 is shown in Figure 2. The highest temperature was observed in the Republic of Turkmenistan, and the lowest - in the Republic of Tajikistan.

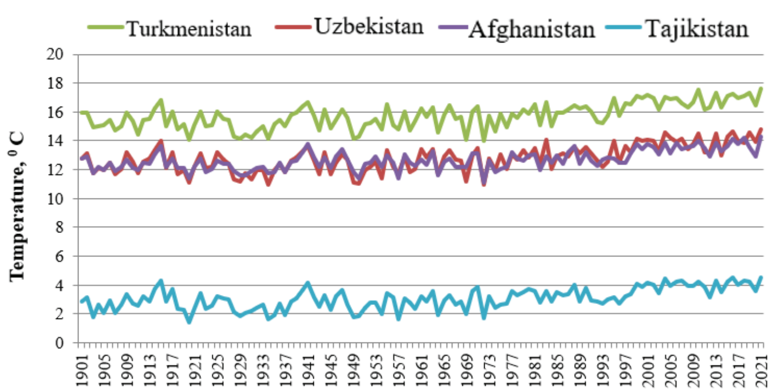

Fig. 2. Changes in the average annual air temperature from 1901 to 2021 in the countries of the Amu Darya Basin.

The average annual precipitation in the Amu Darya basin over 120 years is shown in Figure 3, while Figure 4 shows the annual precipitation in the countries around the basin.

The maximum amount of precipitation over 120 years of observations (the wettest year) was 352.8 mm in 1969, and it was above the norm at almost all stations (except the northwest). The minimum value was observed in 1917 and amounted to 112.9 mm (Figure

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3). Fluctuations in mean annual precipitation in the Amu Darya basin can be divided into two parts.

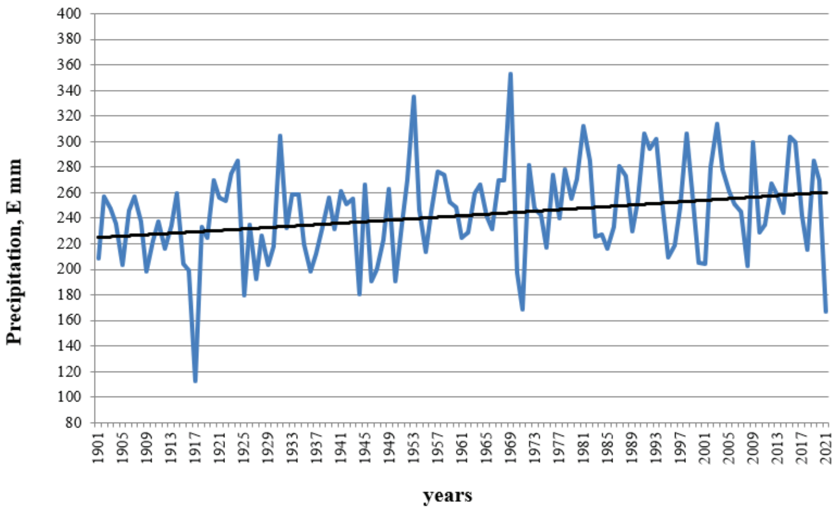


Fig. 3. Changes in mean annual precipitation in the Amu Darya basin from 1901 to 2021.

In the first part, from 1901 to 1950, the amount of precipitation fluctuated from 30 mm to 105 mm and continued at a steady pace. In the second part, from 1951 to 1921, the amount of precipitation fluctuated from 105 mm to 108 mm and increased with frequent high and low precipitation. From the linear trend of average rainfall, it can be seen that from 1901 to 2021, the amount ranged from 30 mm to 108 mm, and the average rainfall increased by 460 mm.

The average annual precipitation from 1901 to 2021 has an inverse shape for the mountainous (Tajikistan) and flat (Turkmenistan, Uzbekistan, and Afghanistan) parts of the Amu Darya basin. Precipitation peaked in the 1950s and 1960s and then began to decrease. At the same time, their annual sum is 3-4 times higher than in the flat area, and the fluctuations themselves occurred within 400-460 mm (Figure 4).

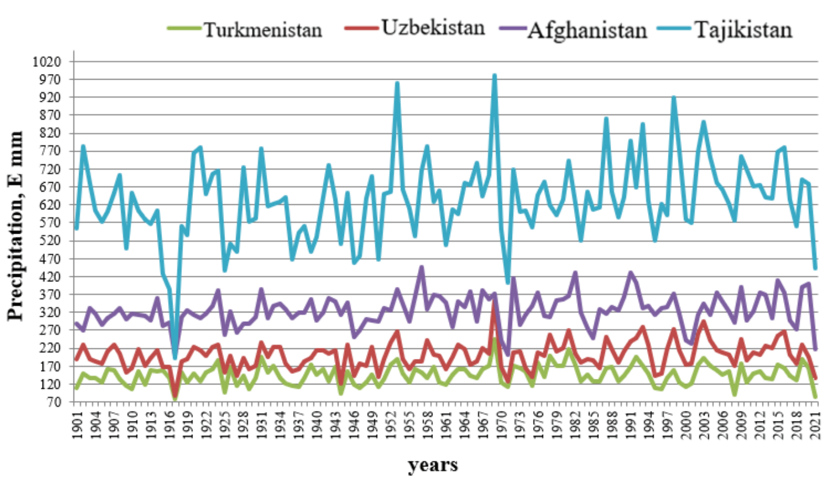
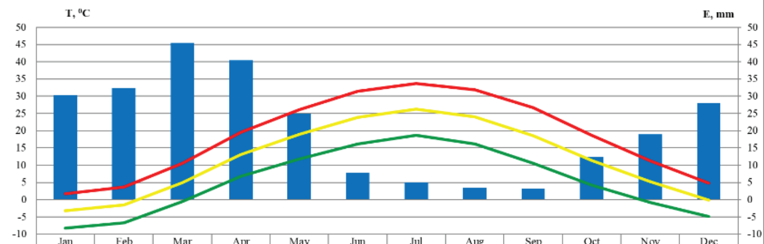


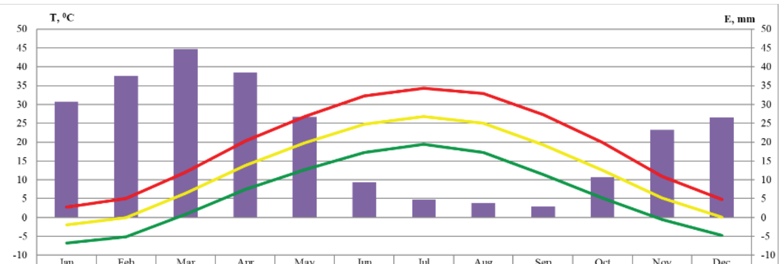
Fig. 4. Average annual precipitation in the countries of the Amu Darya basin from 1901 to 2021 (E, mm).

The graph of maximum, minimum and average monthly temperature and precipitation in the Amu Darya basin is divided into two parts, data from 1961 to 2020 are presented in Figures 5 and 6. It can be seen from the graphs that the amount of precipitation is maximum in March and minimum in September. The hottest days of the year are in June, the coldest in January. It can be seen that the average monthly temperature from 1991 to 2020 increased by 1°C compared to the period from 1961 to 1990.



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Precipitation in 1961-1990	30,29	32,3	45,43	40,49	24,83	7,74	4,98	3,35	3,21	12,38	18,92	27,94
temperature in 1961-1990	-3,27	-1,56	4,94	13,09	18,93	23,82	26,2	23,98	18,58	11,39	5,18	-0,05
min_Temperature in 1961-1990	-8,21	-6,76	-0,59	6,76	11,78	16,16	18,68	16,2	10,51	4,18	-0,83	-4,9
max_Temperature in 1961-1990	1,65	3,62	10,5	19,47	26,12	31,52	33,77	31,82	26,7	18,64	11,21	4,81

Fig. 5. Average monthly precipitation and temperature in the Amu Darya basin from 1961 to 1990.



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Percipitation in 1991-2020	30,8	37,6	44,8	38,46	26,73	9,44	4,86	3,79	2,87	10,66	23,2	26,56
Temperature in 1991-2020	-1,96	-0,06	6,44	13,84	19,77	24,72	26,83	25,03	19,35	12,51	5,22	0,07
min_Temperature_1990-2020	-6,72	-5,15	0,86	7,45	12,71	17,21	19,38	17,24	11,37	5,18	-0,5	-4,7
max_Temperature_1990-2020	2,79	5,02	12,04	20,29	26,87	32,28	34,34	32,86	27,38	19,88	10,96	4,83

Fig. 6. Average monthly precipitation and temperature in the Amu Darya basin from 1991 to 2020.

Seasonal water supplies are declining from year to year due to an increase in the number of hot days and accelerated melting of glaciers widespread in the mountains.

From 1979 to 1990, the maximum value of the average annual water discharge at the Dargonat gauging station was 1992.5 m^3/s (1985), the minimum value was 761 m^3/s (1988), and for the periods from 1991 to 2021 its maximum value was 1500 m^3/s (2005), the minimum value was 413 m^3/s (2021). In the period from 1979 to 2021, the average annual water discharge at the Dargonat gauging station decreased by 340 m^3/s (Figure 7).

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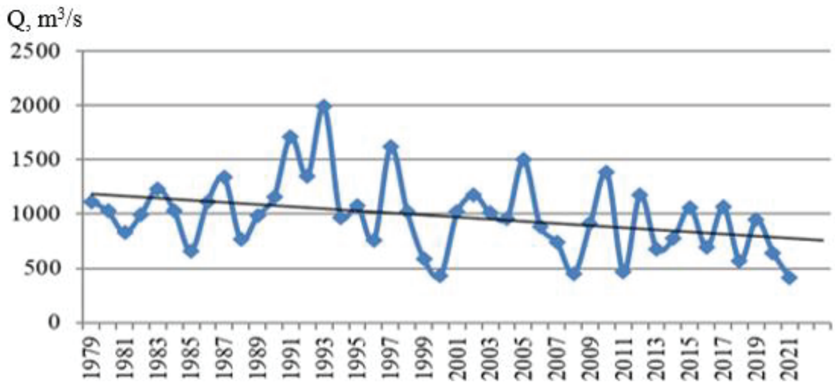

Fig. 7. Dynamics of changes in the average annual water consumption of the Darganat gauging station in 1979 – 2021.

The impact of the heat wave observed in recent years on mountain glaciers is becoming very serious. According to the results of scientific research, it can be seen that the maximum melting limit of glaciers widespread in the mountains has accelerated in some areas, and more slowly in others. It can be seen that due to climate change, water shortage will not be observed in all basins at the same level, but will be associated with the process of reaching the maximum limit of melting of existing glaciers in the provinces.

We see this situation well in the water supply of the river. Amu Darya (Figure 8). Repeatability of dry year cycles At the Darganat gauging station, the annual runoff of less than 25 km^3 is observed 4 times from 1979 to 1999 and 10 times over the past 12 years.

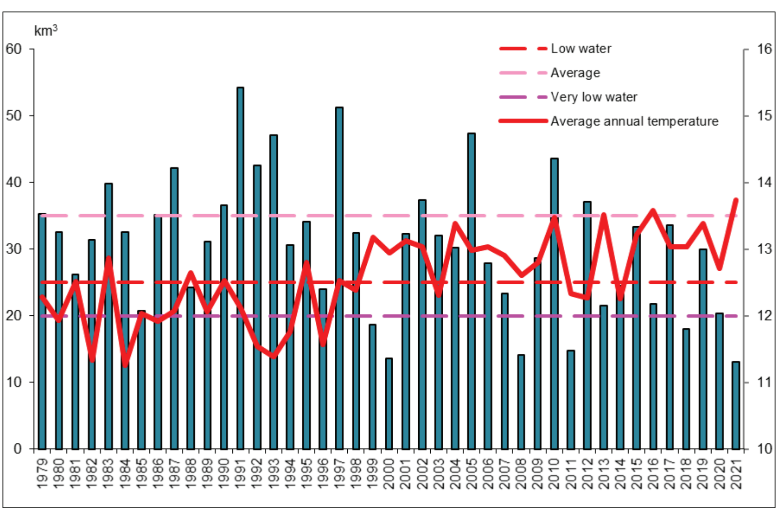

Fig. 8. Dynamics of changes in the annual volume of runoff and air temperature in the Amu Darya Basin in 1979 - 2021 (g/s Dargonata).

4 Conclusions

On the whole, it can be concluded that from 1901 to 2022 two periods of warming were observed (periods before 1940 and after 1976). It can be concluded that the impact of global climate change on the countries of the Amu Darya basin is great.

At the same time, local climatic conditions, especially in mountainous areas, change over a wider range of temperatures. At the same time, the temperature increase over 100 years has reached 2.5 ° C in some provinces, which is much higher than on the entire Earth.

The average amount of precipitation in the province has not changed, but in some areas there is an increase from 1-2 percent to 20-30 percent, as well as a decrease to 40-45 percent.

All this testifies to the urgent practical need to assess global and provinceal climate change, as well as local climate change. Based on the foregoing, in order to mitigate the water problem and save water in the province in dry years, it was proposed:

• phasing transition to water-saving smart irrigation technologies;
• increasing the efficiency of water use;
• using of water saving methods that do not require capital investments;
• improving operational characteristics of furrow irrigation;
• increasing the FIC of hydraulic structures and irrigation systems;
• reducing water consumption by zoning drought-resistant crops

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