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Impacts of regional climate change on hazardous hydrometeorological events in Azerbaijan

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ABSTRACT

Problem definition. Currently observed climate change on Earth is exerting its impacts across all regions. Contemporary warming is manifested more prominently in the mid-latitudes. Over time, changes in the spatiotemporal recurrence of hazardous hydrometeorological events necessitate continuous monitoring of the current state of hydrometeorological elements.

Formulation of the purpose. The article is devoted to the impacts of global climate change on regional climate change in Azerbaijan and the hazardous hydrometeorological events it generates, with particular emphasis on river water resources. Global climate change on Earth is briefly analyzed, and its regional impacts on the territory of Azerbaijan are investigated based on a comparative analysis of recent and long-term historical observational data.

Research methods. In the study, annual indicators of climatic elements were obtained using mathematical and statistical methods. To monitor recent changes, a comparative analysis was conducted between standard climatic values (1961–1990) and corresponding indicators from shorter time periods.

The main material. The study utilizes observational data collected from 61 active meteorological and 84 hydrological stations of the National Hydrometeorology Service operating on the territory of the Republic of Azerbaijan. The dataset covers the period 1961–2025 and includes measurements of various hydrometeorological elements.

Conclusions. The analysis shows that, relative to the long-term climatic norm (1961–1990), the mean annual temperature increase in the country was 1.1°C for the period 1991–2025, while it reached 1.3°C for 2007–2025. However, in 2025 alone, this increase amounted to 1.8°C. For the indicated periods, a continuous decline is observed in both annual precipitation amounts and river discharge. Significant changes in river flow regimes are taking place, including a decrease in discharge volumes during spring–autumn flood and high-water periods, and an increase during low-water winter periods. The dynamics of hazardous hydrometeorological processes causing natural disasters in the country are intensifying in connection with regional climate change. At the same time, it is emphasized that the obtained empirical results should be utilized by the scientific community and taken into account in various applied and planning projects.

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Introduction

Currently, two major natural problems are observed on Earth: the first is atmospheric warming, and the second is the water-related crisis [1, 3], including water scarcity and other hazardous hydrometeorological events arising under the influence of climate change [29].

In the contemporary period, one of the most critical issues concerning the global population [11], state and scientific communities, and

international organizations is global climate change and the increasing negative impacts it exerts on the environment, particularly on the world's water bodies [21]. Climate change and the resulting economic damages to water resources [15], populations [3], biodiversity, agriculture, and infrastructure sectors, as well as the natural disasters it generates, represent one of the most significant natural challenges facing humanity [11, 28].

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Climate change also leads to fluctuations in sea levels, desertification, an increase in forest fires, regime changes in surface and groundwater resources, and a reduction in snow, ice, and freshwater reserves [2, 4, 24–25]. In addition, it contributes to the emergence of problems in human lifestyle and health, thereby posing a wide range of challenges that must be addressed by the global community [16, 23].

According to data from the World Meteorological Organization, 80–85% of natural disasters occurring worldwide are associated with hydrometeorological processes, and 20 of the last 22 years have been classified as warm years characterized by persistent temperature increases [30]. The period 2006–2025 represents the warmest interval of the last 1,500 years, with high temperature values recorded in most regions of the world [10, 14]. Record high temperatures have also been accompanied by an increase in the dynamics of hazardous hydrometeorological events in many regions of Azerbaijan [20, 25].

At the regional scale, these problems manifest at different levels and, naturally, are more clearly expressed in Azerbaijan, which has a distinct physical-geographical and hydrometeorological setting. This is particularly evident in the long-term regime of the country's climate and water bodies, as well as in the occurrence of extreme precipitation, floods, mudflows, hail, droughts, forest fires, and other hazardous hydrometeorological events [5, 14].

Climate is a complex system, and the causes of its change are associated with both natural and anthropogenic factors [13, 29]. Thus, even in periods when human civilization did not exist, natural climate variations occurred on Earth. In this context, periodic changes in the Earth's orbital trajectories, variations in magnetic poles, strong volcanic eruptions, and physical processes occurring on the Sun are among the natural factors contributing to climate change [27]. At present, however, anthropogenic influences have significantly accelerated this process. The expansion of agriculture, industry, and urbanization has, in turn, affected the Earth's energy balance, leading to observable changes in the climate system [2].

The climate of the territory of Azerbaijan is also an integral part of the global climate system, and processes occurring within this system affect the country's climatic conditions with varying intensity and over different time scales [18, 26]. Therefore, the study of climate change, the assessment of its impacts on various sectors of the economy, and the investigation of adaptation capacities of the economic and production systems have become an important issue requiring urgent attention for Azerbaijan and its economy. In

this regard, the United Nations Climate Change Conferences of the Parties held in Azerbaijan in 2024 and in Brazil in 2025 (COP-29 and COP-30) play a significant role in addressing these challenges [7].

Multiple impacts of climate change are already evident in the territory of the Republic of Azerbaijan. Previously, studies conducted by N.Sh.Huseynov, F.A.Imanov, R.N.Mahmudov, S.H.Safarov, A.S.Mammadov, J.S.Huseynov, and other researchers focused on climate-forming factors such as atmospheric precipitation, air temperature, snow cover, drought, and related variables in Azerbaijan. However, earlier studies did not investigate the impacts of climate change on individual hydrometeorological processes in recent years. Therefore, this study examines the recent impacts of climate change on hydrometeorological processes and identifies scientifically significant results for the academic community.

The aim of the study is to assess the impacts of regional climate change on the territory of Azerbaijan and to conduct a long-term analysis of the hazardous hydrometeorological events it generates.

Materials and methods

The methodology of the study is based on the comparative spatiotemporal analysis of long-term hydrometeorological observational data. Some calculations rely on statistical analysis, geographical interpolation, and specific empirical formulas. The data base of the study consists of long-term observational records from approximately 61 conventional and automatic meteorological stations and 85 hydrological sites operating in the territory of Azerbaijan, covering the period 1961–2025. In the methodological analysis, the homogeneity of meteorological and hydrological series was tested, and their statistical parameters were determined. Such analyses ensure an appropriate physical-statistical assessment of regional climate change and the natural disasters it generates.

Descriptive statistics, linear regression analysis, and the non-parametric Mann–Kendall trend test were applied to analyze hydrological and climatic time series in the study. Descriptive analysis was used to evaluate variability through the mean value, standard deviation, and coefficient of variation. To assess trends, the parametric linear regression model (formul 1) was applied, and the trend coefficient and coefficient of determination were calculated. The statistical significance of the trend was tested based on the t-test. In addition, non-parametric trend analysis was performed using the Mann-Kendall test,

which is independent of the normality of data distribution. This approach made it possible to evaluate both the linear rate of change and the reliability of monotonic trends in hydrological and climatic data.

During the study, the linear model presented in Formula 1 was used to evaluate the temporal trend:

$$y=a+bx \quad (1)$$

Here, x represents the independent variable, b denotes the direction and rate of the trend, and a is the constant term. In this model, y represents the hydrological or meteorological variable (temperature, precipitation, or runoff), x denotes time (year), a represents the intercept, and b expresses the trend coefficient (slope).

In this process, the mean values of hydrometeorological parameters were calculated based on Formula 2:

$$\bar{x} = \sum_{i=1}^n x_i \quad (2)$$

Here, $\bar{x}$ denotes the mean value, (x_i) represents the i -th observation, and (n) is the number of observations. The standard deviation was calculated based on Formula 3.

$$\sigma = \sqrt{\frac{1}{n-1} \sum_{i=1}^n (x_i - \bar{x})^2} \quad (3)$$

Here, σ -denotes the standard deviation, (x_i) represents the i -th observation, $(\bar{x})$ -is the mean value, and (n) is the number of observations.

In the study, Formula 4 was used for calculating the coefficient of variation.

$$CV = \frac{\sigma}{\bar{x}} * 100 \quad (4)$$

Here, CV denotes the coefficient of variation (%), (σ) is the standard deviation, and $(\bar{x})$ represents the mean value. The coefficient of determination was calculated using Formula 5.

$$R^2 = 1 - \frac{\sum (y_i - \hat{y}_i)^2}{\sum (y_i - \bar{y})^2} \quad (5)$$

Here, (R^2) denotes the coefficient of determination, (y_i) represents the observed (actual) values, $(\hat{y})$ represents the model-fitted values, and $(\bar{y})$ denotes the mean value.

To assess the statistical significance of the trend, the Mann-Kendall test was applied. In the study, Formulas 6-9 were used to calculate the S statistic, the sign function, the variance, and the Z statistic.

$$S = \sum_{i=1}^{n-1} \sum_{j=i+1}^n \text{sgn}(x_j - x_i) \quad (6)$$

$$\text{sgn}(\theta) = \begin{cases} +1, & \theta > 0 \\ 0, & \theta = 0 \\ -1, & \theta < 0 \end{cases} \quad (7)$$

$$\text{Var}(S) = \frac{n(n-1)(2n+5)}{18} \quad (8)$$

$$Z = \begin{cases} \frac{S-1}{\sqrt{\text{Var}(S)}}, & S > 0 \\ 0, & S = 0 \\ \frac{S+1}{\sqrt{\text{Var}(S)}}, & S < 0 \end{cases} \quad (9)$$

In the above formulas, (x_i) denotes the observation for the i -th year, (n) represents the number of observations, $(\bar{x})$ is the mean value, (S) is the Mann-Kendall statistic, and (Z) denotes the standardized test statistic [6, 12].

Discussion

1.1. Changes in Temperature and Precipitation. In Azerbaijan, the mean multi-year air temperature for the period 1991-2025 increased by +1.1°C relative to the long-term climatic norm (1961–1990), while for the period 2007–2025 it increased by +1.3°C.

In the study, both parametric and non-parametric trend analyses indicated a statistically significant increase in mean annual air temperature in Azerbaijan during 2007-2025. Based on linear regression analysis, the rate of temperature increase was 0.0867°C per year ($\approx 0.87^\circ\text{C}/10\text{year}$, $p < 0.001$). The coefficient of determination ($R^2 = 0.646$) shows that a substantial portion of temperature variability is explained by the time factor. The Mann-Kendall test also confirmed the presence of a positive trend with high statistical significance ($Z = 3.80$; $p < 0.001$). These results demonstrate a persistent regional warming process observed in Azerbaijan over the last two decades.

In the globally recognized warmest years-2018, 2023, and 2025 the mean annual air temperature in the country increased by +2.0°C, +2.2°C, and +1.8°C, respectively. Figure 1 presents the trend of mean multi-year air temperature in the territory of Azerbaijan for the period 2007-2025.

As shown in Figure 1, during this period a general increasing trend in air temperature is observed across the territory of the country. The only exception is 2011, when no increase in mean annual temperature was recorded. Table 1 presents the changes in mean multi-year temperature across different altitude intervals for the periods 2007–2025 and 2025. As can be seen from Table 1, the increase in mean multi-year temperature relative to the climatic norm is +1.0°C in the ≤ 0 m altitude zone. The highest temperature increase (+1.5°C) is observed in the 1–200 m and >1000 m elevation intervals. However, in 2025 the mean annual temperature increase reached +1.8°C. In this year, the

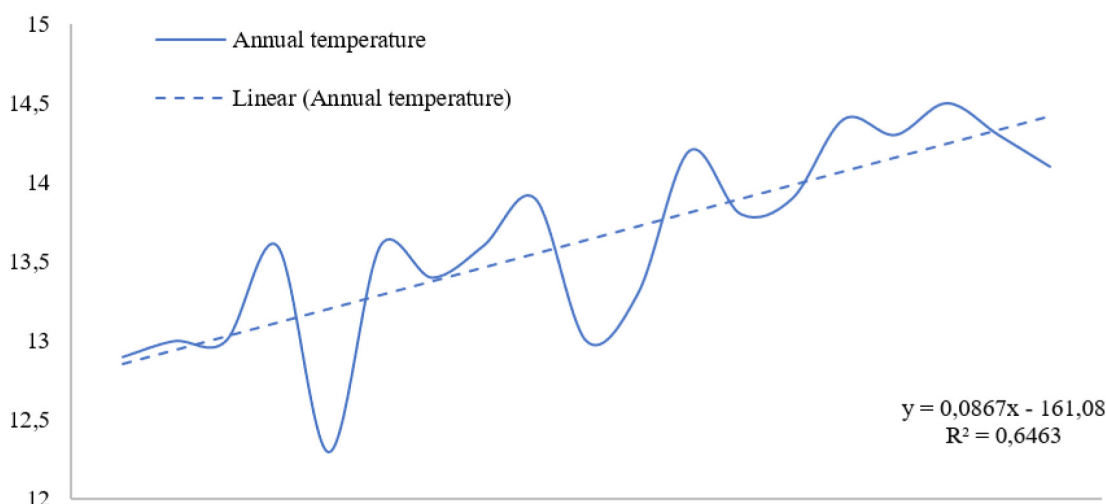


Fig. 1. Trend of mean annual air temperature in the territory of Azerbaijan

maximum temperature increase (+2.1°C) was recorded in the 1–200 m elevation interval.

The analysis of seasonal temperatures in 2025 shows that, relative to the long-term climatic norm, air temperature increased by +2.1°C in winter, +2.0°C in summer, and +1.4°C in autumn, while in spring, conversely, a decrease of 0.8°C was recorded. This further confirms the results of studies conducted over the last 20 years. These studies indicate that, although mean temperature values have increased across all seasons relative to the norm, no increase is observed specifically during the spring season.

The statistical analysis of annual precipitation for the period 2007–2025 revealed an overall decreasing trend in precipitation amounts. The long-term mean precipitation was 449 mm. Based on linear regression analysis, precipitation decreased at an average rate of 6.54 mm per year, or approximately 65 mm per decade. The statistical significance of the trend was confirmed by parametric analysis ($p < 0.05$). The Mann-

Kendall non-parametric test also indicated that the negative trend is statistically significant ($Z = -2.17$; $p < 0.05$). In particular, the minimum precipitation values recorded in 2021–2022 suggest an intensification of drought conditions in recent years. Overall, the results demonstrate that regional climate change has had a significant impact on the precipitation regime.

Figure 2 presents the dynamics of mean annual precipitation in the territory of Azerbaijan for the period 2007–2025. Regarding annual precipitation, a decrease of 37.0 mm has been observed compared to the long-term norm (476 mm). For the period 2007–2025, the highest increase in precipitation across the country was recorded in 2016 (+110 mm), while the maximum decrease occurred in 2017 (-101 mm) [19, 20, 21].

As shown in Figure 2, a decreasing trend in precipitation dynamics is observed in recent years across the territory of the country. Compared to the long-term climatic norm (476 mm), this decrease amounts to 37 mm for the period

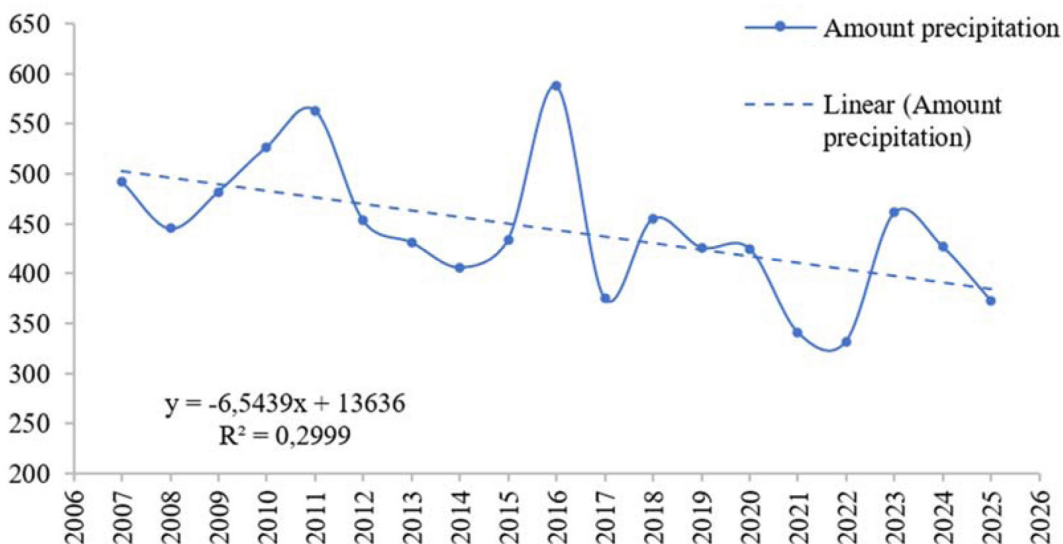


Fig. 2. Precipitation trend in the territory of the Republic of Azerbaijan

Table 1

Changes in mean multi-year air temperature across different altitudinal intervals in the territory of Azerbaijan

Periods	Elevation intervals, m					Republic
	≤ 0	1-200	201-500	501-100	>1000	
Norm 1961-1990	14.6	14.3	13.3	11.9	7.8	12.3
2007-2025	15.6	15.8	14.6	13.1	9.3	13.6
Anomaly	+1.0	+1.5	+1.3	+1.2	+1.5	+1.3
2025	16.1	16.4	15.3	14.3	9.0	14.5
Perennial anomaly	+1.5	+2.1	+2.0	1.9	1.2	1.8

2007–2025. It is noteworthy that, although both increases and decreases in precipitation are observed in different years across various elevation intervals, a consistent decrease throughout all years is recorded only in the 200-500 m altitude range [9, 10].

Table 2 presents the main indicators of extreme hydrometeorological events observed in recent years in the territory of Azerbaijan.

As can be seen from Table 2, during the indicated period, the maximum air temperature in the country was 44.2°C in 2021, and the minimum temperature was -240C (2020). The highest frequency of flood and hail events was in 2023, with 140 hail and 147 flood events.

1.2. Impact of climate change on river flows. The river water system and water resources of any country are the product of climate (Ismayilov & Suleymanov, 2024). Since most countries are located in the same river basins, changes occurring on a global and regional scale have a complex impact on the water resources of the countries of the region. 53 countries on Earth are in the same river basin, and 33 countries are countries experiencing water shortage problems, and Azerbaijan is among these countries [4, 17]. According to a recent study by the World Resources Institute, Azerbaijan is ranked 59th among 164 countries that will face a decrease in water resources by 2050 and is classified as a country with a medium-high (20-40% water stress) risk category. In the 20th century, the

demand for water worldwide has increased more than 6 times. The main reasons for this include, **first**, global climate change and its impact on the world's water resources; **second**, the growth of the global population and the increasing demand for water; and **third**, the intensification of anthropogenic pressures—particularly the discharge of wastewater from industry, agriculture, and domestic use—which leads to changes in both the quantity and quality of water resources. Naturally, there are also other secondary contributing factors. As a result of these challenges, the United Nations designated the period 2018-2028 as the “Water for Sustainable Development” decade [31].

Since Azerbaijan is mainly located within the Kura-Araz river basin, particularly in the lower reaches of these transboundary rivers, the preservation of both the quantity and quality of water resources from these rivers, as well as domestic river systems, is implemented through necessary state-level measures and projects to meet the population's water demand. In this regard, the approval of the “National Strategy on Efficient Use of Water Resources” covering the period 2024-2040 can be considered an indicator of a comprehensive approach to addressing the issue. In order to implement this 16-year National Strategy, an Action Plan has been developed, encompassing measures aligned with relevant priority directions. The Strategy emphasizes

Table 2

Extreme hydrometeorological parameters in the territory of Azerbaijan

Meteorological elements	Years					
	2020	2021	2022	2023	2024	2025
Maximum temperature, (°C)	42.2	44.2	43.3	42.6	43.4	42.9
Minimum temperature, (°C)	-24.0	-20.0	-20.0	-22.9	-19.0	-22.7
Daily maximum precipitation, mm	108	144	83.0	163	274	194
Monthly maximum precipitation, mm	234	394	274	50	30	507
Maximum wind speed, m/s	38	38	40	40	40	33
Maximum height of the abdomen, sm	88	56	80	95	54	75
Number of flood events	36	41	50	147	110	31
Number of hail events	53	34	37	140	106	61

a number of key objectives aimed at eliminating the causes of water losses in the country. For example, it sets targets to expand the application of modern irrigation methods to reach 10% nationwide by 2027, increase drinking water supply coverage to 85% and irrigation water supply to 90% through the development of water supply infrastructure, promote the use of alternative water sources, and reduce losses in drinking water supply to 33% and irrigation water losses to 42% [12, 15].

In order to use Azerbaijan's water resources more efficiently under the current conditions, it is advisable to implement the following measures in accordance with the requirements of the National Water Strategy:

- Reduction of both natural losses (utilization of water accumulated in basin depressions after rainfall and snowmelt, a practice widely used in international experience) and artificial losses within river basins;
- Reassessment of water resources based on innovative technologies;
- Assessment of regional climate change and its impacts on water bodies, as well as the development of relevant scenarios;
- Assessment of potential risks related to water sources;
- Digitalization of spatial data on water sources based on satellite technology;
- Implementation of an optimal infrastructure and management model for water basins;
- Improvement of the early warning system for the timely dissemination of operational information on floods, inundations, and other natural disasters to government agencies and the public;
- Integrated management of water resources both within river basins and between basins;
- Identification and utilization of alternative water sources;
- Establishment of wastewater recycling and management systems.

Despite this, the increasing demand for water in the Republic and its relatively limited water resources make the resolution of water-related issues more urgent. These conditions, in turn, require the continuous study of water bodies and the implementation of water management policies in line with contemporary requirements.

Azerbaijan's total water resources are estimated at around 30 km³. Under the influence of contemporary climate change, the annual river runoff has decreased by 15–20%, and in some transboundary rivers even by up to 40%, making this indicator particularly lower in dry years. Currently, renewable freshwater resources amount to 26.2 billion m³. Of this, 8.5 billion m³ is formed from groundwater, 4.6 billion m³ from local river runoff, and 13.2 billion m³ from transboundary surface waters [19].

The country's water resources account for 15% of the total water resources of the South Caucasus. Per capita water availability is 8.3 times lower than in Georgia and 1.7 times lower than in Armenia. Local water resources amount to 10 km³, transboundary water resources to 20.6 km³, and groundwater resources to 8.5 km³. However, a decrease of 4.4% in groundwater resources, up to 15% in river waters, and 35–40% in transboundary river waters has been observed. The average annual discharge of the Kura River is estimated at 17 km³, of which 9–10 km³ is formed in Georgia, 5–6 km³ in Azerbaijan, 1.5 km³ in Armenia, and 3.4 km³ in the upper reaches within the territory of Türkiye. The total water resources of the Kura-Araz basin are estimated at 25.9 km³, of which 17 km³ is formed in the Kura basin and 8.9 km³ in the Araz basin. The average annual runoff of rivers directly flowing into the Caspian Sea is 1.1 km³ from the northeastern slopes of the Greater Caucasus and 1.3 km³ from the Lankaran-Astara zone. Naturally, a decreasing trend is also observed in the runoff of these rivers. In general, although the long-term average discharge of the Kura River is 450–500 m³/s, this indicator has decreased to 277 m³/s for the period 2011–2025. There are about 450 lakes in the territory of Azerbaijan with a total area of 394 km², of which only 10 lakes have an area exceeding 5 km².

Studies show that, although in some individual years an increase in floods and river discharge is observed, the flood and high-water period flow volumes as well as maximum discharges in rivers continue to decrease. A similar process is also observed in the rivers of Eastern Europe [8, 23].

Taking into account the impacts of regional climate change, trend analyses of annual river discharges (Q_m , m³/s) and maximum water discharges (Q_{max} , m³/s) were conducted based on both observed and reconstructed hydrological series for rivers located within the territory of the country. As examples, Figures 2 and 3 present the long-term variation graphs of mean annual and maximum discharges of the respective rivers.

The statistical analysis of mean annual streamflow at the Kur-Giragkasaman station for the period 1981–2025 was conducted using both parametric (linear regression) and non-parametric (Mann-Kendall) methods. The results of the parametric analysis indicated a statistically significant decreasing trend in annual streamflow (slope = -1.93 yr^{-1} , $p = 0.0095$). The non-parametric Mann-Kendall test confirmed the same result ($Z = -2.44$, $p = 0.0148$), indicating that the trend is robust and independent of the data distribution. Sen's slope estimate (-1.72 yr^{-1}) quantified the magnitude of the average annual decrease in streamflow.

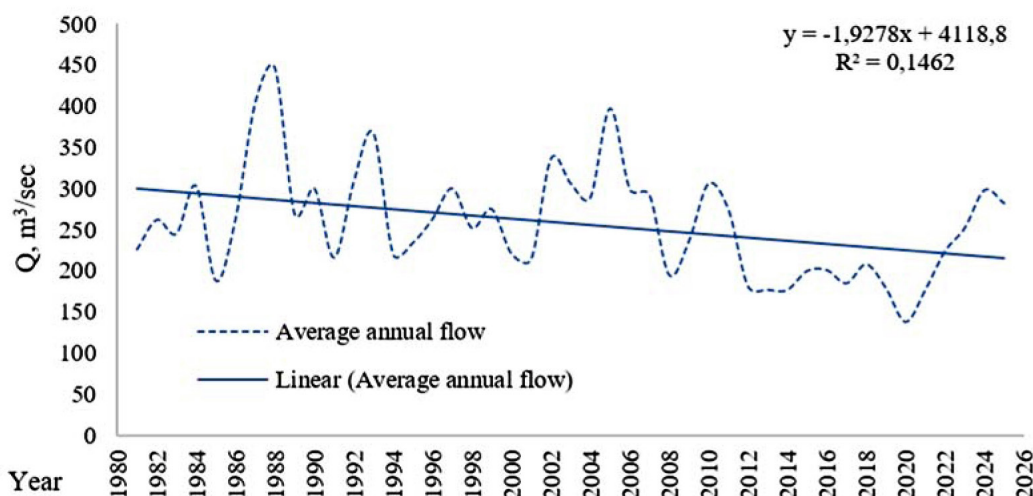


Fig. 3. Trend of average multi-year water consumption in the Kura-Giragkasaman area

Overall, the consistency of both methods demonstrates the presence of long-term hydrometeorological changes in the Kura River basin and a gradual weakening of the streamflow regime. These changes are associated with climate change, increased evaporation, and intensified anthropogenic water use.

The statistical analysis of annual maximum streamflow at the Kur-Giragkasaman station for the period 1981-2025 revealed an overall decreasing trend against a background of strong variability. The mean annual maximum discharge was 1150.2 m³/s; however, interannual variability was high (CV=40.6%). Linear regression analysis indicated an average annual decrease of 11.66 m³/s, while the low coefficient of determination ($R^2 = 0.108$) suggests that this variation is strongly influenced by stochastic components. Nevertheless, the Mann-Kendall non-parametric test confirmed that the decreasing trend is statistically significant ($Z = -2.47$; $p = 0.013$). These results indicate a weakening tendency of peak discharge in the Kura River system in recent decades and reflect ongoing changes in the hydrological regime.

As shown in Figures 3 and 4, both the long-term river discharge and the maximum flow rates of the basin rivers are decreasing under the influence of regional climate change. The observed changes in river flow regimes indicate that while discharge volumes during spring–summer flood and high-water periods are declining, winter low-water flows are, conversely, increasing. This can be explained by the fact that snow and ice water reserves, which play a key role in runoff formation, are partially converted into river discharge during the winter period due to rising average winter temperatures. As a result, a decrease in maximum discharges during flood and high-water periods is also observed.

As indicated in the National Water Strategy of the country, due to the impacts of climate change, water resources are expected to decline to 20.1 km³ by 2040, including a reduction of surface water resources to 11.6 km³. Consequently, the existing water deficit in the country is projected to increase from 4.0 km³ to 8.0 km³. Ensuring the population's and economic sectors' water supply, as well as the efficient and rational use of water

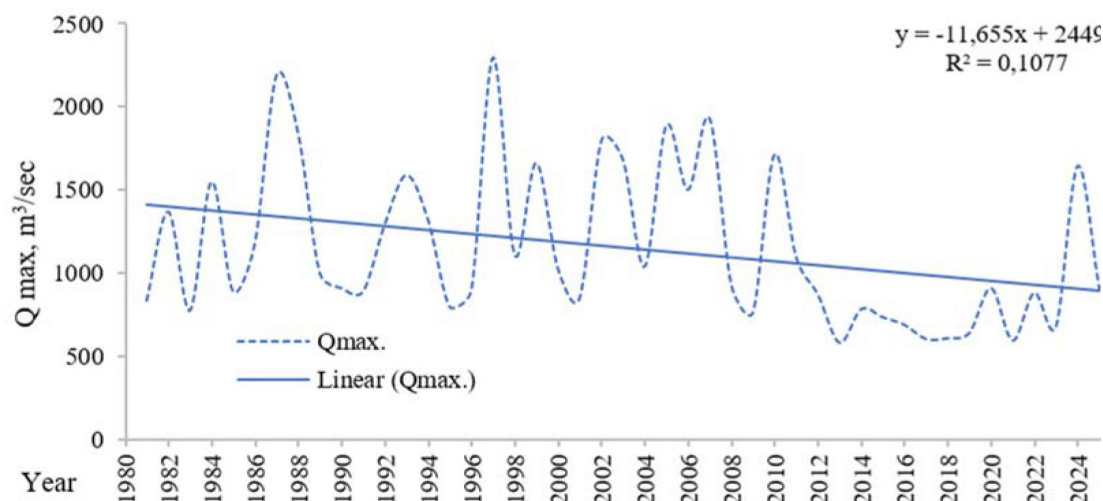


Fig. 4. Trend of maximum water consumption at the Kura-Giragkesaman point

resources, has always been one of the priority directions of Azerbaijan's water policy.

One of the water-related problems of our country is undoubtedly the fluctuation of the Caspian Sea level, more precisely its significant decline in recent years. Historically, the level of the Caspian Sea has always fluctuated with a large amplitude in response to climatic changes. Studies show that over the last 2,000 years, the sea level has varied within an amplitude of about 12 m. Over the last 300 years, this amplitude has been about 5 m, fluctuating approximately between -25 and -30 m relative to sea level. Thus, in 1882 the maximum level reached -25.2 m, while from 1929 to 1977 it decreased to -29.05 m. From 1977 to 1995, the level rose again by 2.65 m, reaching -26.04 m. Between 1995 and 2010, the sea level remained relatively stable, after which it began to decline again, reaching approximately -29.04 m by 2024 [1].

Historically, fluctuations in the Caspian Sea level have been closely linked to its water balance—comprising river inflow into the basin, evaporation from the surface, and precipitation over the basin—and to climatic changes occurring within the catchment area. Approximately 80–85% of the total annual river inflow to the Caspian Sea is contributed by the Volga River. Studies indicate that when the long-term average discharge of the Volga River is 330–350 km³/year, the sea level tends to rise; at 240–250 km³/year it remains relatively stable; and at 120–140 km³/year a declining trend is observed. A similar pattern is also reflected in other rivers flowing into the Caspian Sea. If the Caspian Sea level were to reach its historical minimum (–30 m a.s.l.), significant shoreline retreat would occur along Azerbaijan's Caspian coastal areas: approximately 4–5 km in the Nabran-Shabran zone, 10–12 km in the Sangaçal–Alat area, and 2–3 km in the Lankaran region. Such changes would create major challenges for maritime infrastructure, navigation, and the ecological environment. In addition, the merging of nearshore islands could occur, while water exchange in the Baku Bay may decrease by 3–4 times.

1.3. Flood event. The territory of Azerbaijan is considered one of the 20 countries in the world where flood hazard is most frequently observed. Flood events are mainly recorded in the Shaki-Zagatala, Nakhchivan, and high-mountain regions of the country, where both turbulent and structural types of floods occur. Numerous studies have been conducted on flood events in Azerbaijan, and the “Flood Catalogue” and “Flood Map” (2016), covering the period 1772–2025, have been published [19]. In the territory of the Republic, approximately 85% of flood events are formed due to intense rainfall, 10% due to mixed water sources, and only 5% due to snowmelt. In regional rivers, particularly in the Kish River and

its tributaries, the annual sediment transport can reach 200–300 tons. The highest frequency of floods within a month occurs in both the Greater and Lesser Caucasus river systems during June and July, accounting for 31.2% and 28.0% of the annual flood discharge, respectively.

In 2020, a total of 36 flood events occurred in the territory of the country (2 in May, 2 in June, 23 in July, and 9 in August). The most hazardous events were recorded on May 10 in the Hasan Su River of the Aghstafa district, on August 2 in the Kurmuk River, and on August 15 in the Kish River.

In 2021, a total of 41 flood events were recorded (8 in May, 3 in June, 16 in July, 1 in August, 8 in September, and 5 in October). The most hazardous events occurred on June 6 in the Kish River, on July 7 in the Shamkir River, and on September 23 in the Tala, Balaken, and Katekh rivers.

In 2022, a total of 50 flood events were recorded (1 in March, 3 in April, 18 in May, 19 in June, 2 in July, 2 in August, 4 in September, and 1 in October). The most hazardous flood events were observed on May 9 in Shamakhi, on June 10 in the Ganja River, and on June 22 in Goranboy.

In 2023, a total of 147 flood events occurred (7 in April, 12 in May, 59 in June, 16 in July, 7 in August, and 46 in September). The most hazardous flood events were recorded on May 25 in the Ganja River, on June 30 in the Dashkasan district, and on August 26 in the Goychay district.

In 2024, 110 flood events were recorded in the territory of the country (12 in May, 47 in June, 43 in July, 7 in October, and 1 in November). The most hazardous floods occurred in the river basins of the Kura River, including the Gazakh, Aghstafa, and Khram tributary rivers.

In 2025, a total of 21 flood events were recorded (17 in April, 3 in May, and 1 in June). The intensity of these flood events was relatively weak.

1.4. Hail event. In Azerbaijan, hail events are observed mainly on the southern slope of the Greater Caucasus, the northern slope of the Lesser Caucasus, and in Nakhchivan. In the high mountainous areas of the Greater Caucasus (2300–2800), the number of hail events per year is 8–10 days, in the Lesser Caucasus 10–12 days, and in Nakhchivan and Karabakh 5–7 days. By month, the highest recurrence of hail in the country mainly occurs in May–June due to the increase in temperature and humidity, and the dynamics of convective processes related to orographic conditions. In recent years, the intensity and recurrence of hail events have increased due to the impact of global climate change, and sometimes large-diameter hail and ice fragments fall [20].

In 2020, 53 hail events were recorded in Azerbaijan, with an average hailstone diameter of 10–15 mm, and in some cases reaching 20–22

mm. The maximum hailstone diameter of 30 mm was observed on 15 September 2020 in the Zagatala region.

In 2021, the number of hail events was 34, with an average hailstone diameter of 8-10 mm, while the maximum diameter of 25 mm was recorded in the Dashkasan region.

In 2022, hail events were recorded over 37 days, with an average diameter of 10-12 mm and a maximum diameter of 16 mm observed in the Gadabay-Dashkasan area.

In 2023, a record 140 days of hail events were observed across different regions of the country. The highest frequency occurred in April (57 days), May (40 days), and July (43 days). The average hailstone diameter ranged between 5-15 mm, while the maximum hailstone size reached 30–35 mm in Gabala (01.06.23) and Aghdam (18.06.23). In Zagatala, hail with a diameter of 25 mm was recorded on 30.04.23 and 07.09.23.

In 2024, a total of 106 hail events were observed. The average hailstone diameter ranged from 8-14 mm, while the maximum diameter reached 30 mm, recorded in Zagatala on 07.06.24 and 18.05.24.

In 2025, 61 hail events were recorded, with an average hailstone diameter of 9–12 mm. The maximum hailstone size (24 mm) was observed on 27.06.25 in the Gadabay–Dashkasan region.

1.5. Avalanche and drought event. Avalanches caused by climatic and geomorphological factors are considered hazardous natural phenomena for the population, the economic system, the tourism sector, and other infrastructure sectors.

In the world, avalanche hazards exhibit different characteristics across various geographical regions and climatic zones. In recent years, under the influence of contemporary climate change, the dynamics of this process have continued to intensify in high-mountain areas. An avalanche occurs when the snow cover exceeds a thickness of 30-50 cm on steep slopes and moves under the influence of gravity. In some cases, the force exerted on 1 m² along its path can reach tens of tons. The average velocity of an avalanche ranges between 50-90 m/s, while in strong avalanches the flow height may reach 8-10 cm. The critical height of snow leading to avalanching depends on the internal density relationship of snow (*S*), the volume of snow mass (*w*), the internal sliding coefficient of snow (*α*), and the slope gradient, and can be expressed as follows: (Makhmudov et al., 2025).

$$h = \frac{S}{W \cos \alpha (\sin \alpha - \operatorname{tg} \varphi \cos \alpha)} \quad (10)$$

In this formula, as *tgφ* increases from 20° to 35–45°, the critical snow height and the probability of avalanches increase. Conversely, when the slope angle decreases, both the critical snow height and

avalanche likelihood are reduced (Bračko et al., 2022).

In Azerbaijan, avalanche risk is most frequently observed in the high-mountain areas of the Greater Caucasus, Lesser Caucasus, and Nakhchivan. The author of the article has prepared an avalanche hazard map of the country's territory based on the degree of risk. The most dangerous avalanche event occurred on 16 December 2000 in the Hinal Mountain of the Lesser Caucasus physiographic region, resulting in the death of 11 military personnel. Drought events, as hazardous natural factors, are included among the most dangerous phenomena resulting from hydrometeorological processes, particularly spatial variations in climatic indicators as well as negative anthropogenic impacts. One of the main adverse consequences of drought is the intensification of desertification processes. At present, under the influence of global climate change, the dynamics of drought events continue to increase worldwide. In the territory of Azerbaijan, particularly in the arid climatic zones of the Kura-Araz Lowland, the Absheron-Gobustan area, and the Araz river valley regions, persistent drought conditions occur under the influence of regional climate change. In the districts of Ordubad, Julfa, and Babek, drought is observed for 50-70 days per year, in the Sharur-Nakhchivan area for 25–50 days, on the southern slopes of the Greater Caucasus for 15-20 days, and in the Kura-Araz Lowland for 60-80 days. Both atmospheric and soil droughts are observed in Azerbaijan. The most prolonged drought events were recorded in 2015-2018 and in 2024, when the duration of rainless periods reached 2-3 months [18, 19].

Conclusions

The study conducted using hydrometeorological station data operating within the territory of the Republic of Azerbaijan yielded the following results.

1. In the territory of Azerbaijan, during the period 1991-2025, compared to the climatological norm (1961-1990), the mean annual air temperature increased by 1.1°C. For the period 2007-2025, the increase was 1.3°C, while in 2025 alone it reached 1.8°C. In addition, mean annual precipitation decreased by 37 mm relative to the long-term norm, indicating that climate change has intensified over time.

2. In areas above 1000 m elevation within the country, the increase in temperature is more pronounced compared to other altitude intervals. For precipitation, both increases and decreases relative to the climatological norm are observed across all elevation bands; however, a consistent decrease is recorded exclusively in the 200–500 m elevation interval.

3. Under the influence of regional climate change, the mean annual river discharge volumes have decreased by 20-40%. Changes in the annual flow regimes of rivers have been observed, accompanied by increased variability, a reduction in flood discharge volumes, and a decline in peak flows. While winter low-flow conditions have increased, both the magnitude and duration of spring high-flow (flood) periods have decreased.

4. The analyses show that during the period 2020-2025 in the territory of Azerbaijan, 551 flood events and 431 hail events were recorded. The most severe drought occurred in 2024, while the strongest snow avalanche was recorded on December 16, 2000. Such events confirm the spatial and temporal intensification and expansion of the hazardous impacts of climate change.

5. Under the influence of climate change, the decline in the level of the Caspian Sea continues toward a critical threshold. Compared to its recent maximum level in 1995 (–26.04 m), the current level in 2025 (–29.05 m) has decreased by up to 3 meters. The reduction in the Caspian Sea level is explained by the impact of climate change on the

decreasing water levels in inland water basins.

Under the influence of regional climate change, river flow regime alterations are occurring, characterized by a decrease in flood and high-flow (spring runoff) discharges and their peak values, along with an increase in winter low-flow conditions. Currently, there is a 4 km³ deficit in national water resources; however, the National Water Strategy projects that this deficit will increase to 8 km³ by 2040.

Under the influence of climate change, the emergence of spatiotemporal shifts in the recurrence of hazardous hydrometeorological events makes it necessary to periodically update adaptation and mitigation measures in settlement areas. In addition, the development of model-based forecasting and early warning systems across all regions will help reduce the expected safety risks. It is recommended that the results of this study be taken into account in the planning of all settlement, industrial, and tourism sectors. Future research should focus on the long-term forecasting of hazardous hydrometeorological events and the development of improved adaptation programs.

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СПИСОК ВИКОРИСТАНИХ ДЖЕРЕЛ

REFERENCES

1. Aliyev, A. S. (2024). Changes in the level of the Caspian Sea in the modern period. *Proceedings of the Azerbaijan National Academy of Sciences, Series of Earth Sciences*, 80 (1–2). <https://doi.org/10.59423/gnr.2024.83.40.012>
2. Aghakouchak, A., Chiang, F., Huning, L. S., et al. (2020). Climate extremes and compound hazards in a warming world. *Annual Review of Earth and Planetary Sciences*, 48, 519–548. <https://doi.org/10.1146/annurev-earth-071719-055228>
3. Agakishiyeva, G. R., & Samadov, G. M. (2026). Natural factors of tourism development in the Greater Caucasus physical geographical province of Azerbaijan. *Journal of Geology, Geography and Geoecology*, 35(1), 3-13. <https://doi.org/10.15421/112601>
4. Al-Rawas, G., Nikoo, M. R., Janbehsarayi, S. F. M., et al. (2024). Near future flash flood prediction in an arid region under climate change. *Scientific Reports*, 14, 25887. <https://doi.org/10.1038/s41598-024-76232-0>
5. Bashirgonbad, M., Moghaddam Nia, A., Khalighi-Sigaroodi, S., et al. (2024). A hydro-climatic approach for extreme flood estimation in mountainous catchments. *Applied Water Science*, 14, 98. <https://doi.org/10.1007/s13201-024-02149-8>
6. Bračko, T., Žlender, B., & Jelušič, P. (2022). Implementation of Climate Change Effects on Slope Stability Analysis. *Applied Sciences*, 12(16), 8171. <https://doi.org/10.3390/app12168171>
7. Financial Times. (2025, June 8). Eastern European nations pave way for Baku to host COP 29. <https://www.ft.com/content/95965689-d79b-4924-992a-8b4a9d7a8fe6>
8. Gudmundsson, L., et al. (2021). Globally observed trends in mean and extreme river flow attributed to climate change. *Science*, 371(6532), 1159–1162. <https://doi.org/10.1126/science.aba3996>
1. Aliyev, A. S. (2024). Changes in the level of the Caspian Sea in the modern period. *Proceedings of the Azerbaijan National Academy of Sciences, Series of Earth Sciences*, 80 (1–2). <https://doi.org/10.59423/gnr.2024.83.40.012>
2. Aghakouchak, A., Chiang, F., Huning, L. S., et al. (2020). Climate extremes and compound hazards in a warming world. *Annual Review of Earth and Planetary Sciences*, 48, 519–548. <https://doi.org/10.1146/annurev-earth-071719-055228>
3. Agakishiyeva, G. R., & Samadov, G. M. (2026). Natural factors of tourism development in the Greater Caucasus physical geographical province of Azerbaijan. *Journal of Geology, Geography and Geoecology*, 35(1), 3-13. <https://doi.org/10.15421/112601>
4. Al-Rawas, G., Nikoo, M. R., Janbehsarayi, S. F. M., et al. (2024). Near future flash flood prediction in an arid region under climate change. *Scientific Reports*, 14, 25887. <https://doi.org/10.1038/s41598-024-76232-0>
5. Bashirgonbad, M., Moghaddam Nia, A., Khalighi-Sigaroodi, S., et al. (2024). A hydro-climatic approach for extreme flood estimation in mountainous catchments. *Applied Water Science*, 14, 98. <https://doi.org/10.1007/s13201-024-02149-8>
6. Bračko, T., Žlender, B., & Jelušič, P. (2022). Implementation of Climate Change Effects on Slope Stability Analysis. *Applied Sciences*, 12(16), 8171. <https://doi.org/10.3390/app12168171>
7. Financial Times. (2025, June 8). Eastern European nations pave way for Baku to host COP 29. <https://www.ft.com/content/95965689-d79b-4924-992a-8b4a9d7a8fe6>
8. Gudmundsson, L., et al. (2021). Globally observed trends in mean and extreme river flow attributed to climate change. *Science*, 371(6532), 1159–1162. <https://doi.org/10.1126/science.aba3996>

9. Huseynov, J., Tagiyev, A., & Ismayilova, M. (2025). Characteristics of the contemporary spatiotemporal distribution of atmospheric precipitation in the southern and southeastern parts of the Greater Caucasus region. *Visnyk of V. N. Karazin Kharkiv National University. Series Geology. Geography. Ecology*, (62), 360–371. <https://doi.org/10.26565/2410-7360-2025-62-27>
10. Huseynov, N., Huseynov, J., & Guliyev, Z. (2025). The conceptual model of climate change in the republic of Azerbaijan. *Geojournal of Tourism and Geosites*, 61(3), 1875–1886. <https://doi.org/10.30892/gtg.61345-1555>
11. Huseynova, T. (2025). Assessment of the quality of life of the population in Azerbaijan (on the example of the Greater Caucasus). *Visnyk of V. N. Karazin Kharkiv National University. Series Geology. Geography. Ecology*, (63), 172–183. <https://doi.org/10.26565/2410-7360-2025-63-13>
12. Ismayilov, R., & Suleymanov, F. (2024). Water resilience under climate change in Azerbaijan. *Geojournal of Tourism and Geosites*, 53(2), 677–686. <https://doi.org/10.30892/gtg.53231-1243>
13. Intergovernmental Panel on Climate Change (2007). *Climate change 2007: The physical science basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge University Press.
14. Intergovernmental Panel on Climate Change (2021). *Climate change 2021: The physical science basis. Contribution of Working Group I to the Sixth Assessment Report*. Cambridge University Press. <https://doi.org/10.1017/9781009157896>
15. Imanov F., Alakbarov A. (2017). Modern Changes in Azerbaijan's Water Resources and Their Integrated Management. Baku, 345.
16. Kleidon, A. (2024). Droughts in Germany-Why global climate change amplifies hydrological extremes. <https://doi.org/10.1002/piuz.202401697>
17. Lapiques, D. A., Sytsma, A., & Thompson, S. (2021). Implications of distinct methodological interpretations and runoff coefficient usage for rational method predictions. *Journal of the American Water Resources Association*, 57(6), 859–874. <https://doi.org/10.1111/1752-1688.12949>
18. Makhmudov, R. (2022a). *Regional climate changes and hazardous hydrometeorological events in Azerbaijan*. Baku.
19. Makhmudov R. (2022b). Regional climatic changes in Azerbaijan and its impact on hydrometeorological conditions. *Slovak international scientific journal*, 63, 48–54. <https://doi.org/10.5281/zenodo.6535054>
20. Makhmudov, R. N. (2024). Regional climate changes in Azerbaijan and assessment of their impact on water resources with a new method. *Reliability: Theory & Applications*, 19 (Special Issue 6(81), Part 2), 830–837. https://gnedenko.net/Journal/2024/SI_062024/RTA_SI062024-105_49_Rza%20Makhmudov%20Vugar%20Aliyev%20%20Mavlud%20Teymurov.pdf
21. Makhmudov, R., Teymurov, M., Aliyev, V., Agayev, Z., Mammadov, Z., & Gafarov, E. (2025). Baseflow as the underground organizer and regulator of a single river system. *Reliability: Theory & Applications*, 20(Special Issue 9(87)). https://gnedenko.net/Journal/2025/SI_092025/RTA_SI092025_RISK2025-119.pdf
22. McBean, E., & Motiee, H. (2008). Assessment of impact of climate change on water resources: A long-term analysis of the Great Lakes of North America. *Hydrology and Earth System Sciences*, 12, 239–255. <https://doi.org/10.5194/hess-12-239-2008>
23. Musayeva, M., Huseynov, J., & Suleymanov, M. (2025). The analysis of the dependence of characteristics elements of snow on orography on the northeastern slope of the Greater Caucasus. *Visnyk of V. N. Karazin Kharkiv National University. Series Geology. Geography. Ecology*, (63), 289–299. <https://doi.org/10.26565/2410-7360-2025-63-22>
24. Pandey, K., Gandhi, F., Kumar, S., Roy, C., Anand, V., Milentijević, N., Pantelić, M., & Dolinaj, D. (2026). Regional Variability and Spatio-Temporal Dynamics of Groundwater Quality in the Western Himalayas: An Integrated WQI and Hydrochemical Assessment. *Water*, 18(13), 1602. <https://doi.org/10.3390/w18131602>
25. Safarov, S. (2026). Assessment of monthly maximum and minimum air temperature changes tendency in the Nakhchivan Autonomous Republic based on normal values. *Comptes Rendus de l'Académie Bulgare des Sciences*, 79(5), 595–602. <https://doi.org/10.7546/CRABS.2026.05.07>
9. Huseynov, J., Tagiyev, A., & Ismayilova, M. (2025). Characteristics of the contemporary spatiotemporal distribution of atmospheric precipitation in the southern and southeastern parts of the Greater Caucasus region. *Visnyk of V. N. Karazin Kharkiv National University. Series Geology. Geography. Ecology*, (62), 360–371. <https://doi.org/10.26565/2410-7360-2025-62-27>
10. Huseynov, N., Huseynov, J., & Guliyev, Z. (2025). The conceptual model of climate change in the republic of Azerbaijan. *Geojournal of Tourism and Geosites*, 61(3), 1875–1886. <https://doi.org/10.30892/gtg.61345-1555>
11. Huseynova, T. (2025). Assessment of the quality of life of the population in Azerbaijan (on the example of the Greater Caucasus). *Visnyk of V. N. Karazin Kharkiv National University. Series Geology. Geography. Ecology*, (63), 172–183. <https://doi.org/10.26565/2410-7360-2025-63-13>
12. Ismayilov, R., & Suleymanov, F. (2024). Water resilience under climate change in Azerbaijan. *Geojournal of Tourism and Geosites*, 53(2), 677–686. <https://doi.org/10.30892/gtg.53231-1243>
13. Intergovernmental Panel on Climate Change (2007). *Climate change 2007: The physical science basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge University Press.
14. Intergovernmental Panel on Climate Change (2021). *Climate change 2021: The physical science basis. Contribution of Working Group I to the Sixth Assessment Report*. Cambridge University Press. <https://doi.org/10.1017/9781009157896>
15. Imanov F., Alakbarov A. (2017). Modern Changes in Azerbaijan's Water Resources and Their Integrated Management. Baku, 345.
16. Kleidon, A. (2024). Droughts in Germany-Why global climate change amplifies hydrological extremes. <https://doi.org/10.1002/piuz.202401697>
17. Lapiques, D. A., Sytsma, A., & Thompson, S. (2021). Implications of distinct methodological interpretations and runoff coefficient usage for rational method predictions. *Journal of the American Water Resources Association*, 57(6), 859–874. <https://doi.org/10.1111/1752-1688.12949>
18. Makhmudov, R. (2022a). *Regional climate changes and hazardous hydrometeorological events in Azerbaijan*. Baku.
19. Makhmudov R. (2022b). Regional climatic changes in Azerbaijan and its impact on hydrometeorological conditions. *Slovak international scientific journal*, 63, 48–54. <https://doi.org/10.5281/zenodo.6535054>
20. Makhmudov, R. N. (2024). Regional climate changes in Azerbaijan and assessment of their impact on water resources with a new method. *Reliability: Theory & Applications*, 19 (Special Issue 6(81), Part 2), 830–837. https://gnedenko.net/Journal/2024/SI_062024/RTA_SI062024-105_49_Rza%20Makhmudov%20Vugar%20Aliyev%20%20Mavlud%20Teymurov.pdf
21. Makhmudov, R., Teymurov, M., Aliyev, V., Agayev, Z., Mammadov, Z., & Gafarov, E. (2025). Baseflow as the underground organizer and regulator of a single river system. *Reliability: Theory & Applications*, 20(Special Issue 9(87)). https://gnedenko.net/Journal/2025/SI_092025/RTA_SI092025_RISK2025-119.pdf
22. McBean, E., & Motiee, H. (2008). Assessment of impact of climate change on water resources: A long-term analysis of the Great Lakes of North America. *Hydrology and Earth System Sciences*, 12, 239–255. <https://doi.org/10.5194/hess-12-239-2008>
23. Musayeva, M., Huseynov, J., & Suleymanov, M. (2025). The analysis of the dependence of characteristics elements of snow on orography on the northeastern slope of the Greater Caucasus. *Visnyk of V. N. Karazin Kharkiv National University. Series Geology. Geography. Ecology*, (63), 289–299. <https://doi.org/10.26565/2410-7360-2025-63-22>
24. Pandey, K., Gandhi, F., Kumar, S., Roy, C., Anand, V., Milentijević, N., Pantelić, M., & Dolinaj, D. (2026). Regional Variability and Spatio-Temporal Dynamics of Groundwater Quality in the Western Himalayas: An Integrated WQI and Hydrochemical Assessment. *Water*, 18(13), 1602. <https://doi.org/10.3390/w18131602>
25. Safarov, S. (2026). Assessment of monthly maximum and minimum air temperature changes tendency in the Nakhchivan Autonomous Republic based on normal values. *Comptes Rendus de l'Académie Bulgare des Sciences*, 79(5), 595–602. <https://doi.org/10.7546/CRABS.2026.05.07>

26. Sikan, A.V., Imanov, F.A. (2023). Features of formation and long-term fluctuations of the low flow of rivers in the Greater Caucasus. *Advances in Biology & Earth Sciences*, 8(3), 272–287. https://jomardpublishing.com/UploadFiles/Files/journals/ABES/V8N3/Sikan_Imanov_.pdf
27. Sigl, M., et al. (2015). Timing and climate forcing of volcanic eruptions for the past 2,500 years. *Nature*, 523, 543–549. <https://doi.org/10.1038/nature14565>
28. Shayanmehr, S., Porhajašová, J. I., Babošová, M., Sabouhi Sabouni, M., Mohammadi, H., Rastegari Henneberry, S., & Shahnoushi Foroushani, N. (2022). The Impacts of Climate Change on Water Resources and Crop Production in an Arid Region. *Agriculture*, 12(7), 1056. <https://doi.org/10.3390/agriculture12071056>
29. Wang, S., Ancell, B., Yang, Z.-L., Duan, Q., & Anagnostou, E. N. (2022). Hydroclimatic extremes and impacts in a changing environment: Observations, mechanisms, and projections. *Journal of Hydrology*, 608, 127615. [https://doi.org/10.1016/0022-1694\(95\)02739-C](https://doi.org/10.1016/0022-1694(95)02739-C)
30. World Meteorological Organization. (2024a). *State of the global climate 2023*. WMO. <https://wmo.int/publication-series/state-of-global-climate-2023>
31. World Meteorological Organization. (2024b). *Bulletin of the WMO* (No. 2224/163). Geneva, Switzerland.
26. Sikan, A.V., Imanov, F.A. (2023). Features of formation and long-term fluctuations of the low flow of rivers in the Greater Caucasus. *Advances in Biology & Earth Sciences*, 8(3), 272–287. https://jomardpublishing.com/UploadFiles/Files/journals/ABES/V8N3/Sikan_Imanov_.pdf
27. Sigl, M., et al. (2015). Timing and climate forcing of volcanic eruptions for the past 2,500 years. *Nature*, 523, 543–549. <https://doi.org/10.1038/nature14565>
28. Shayanmehr, S., Porhajašová, J. I., Babošová, M., Sabouhi Sabouni, M., Mohammadi, H., Rastegari Henneberry, S., & Shahnoushi Foroushani, N. (2022). The Impacts of Climate Change on Water Resources and Crop Production in an Arid Region. *Agriculture*, 12(7), 1056. <https://doi.org/10.3390/agriculture12071056>
29. Wang, S., Ancell, B., Yang, Z.-L., Duan, Q., & Anagnostou, E. N. (2022). Hydroclimatic extremes and impacts in a changing environment: Observations, mechanisms, and projections. *Journal of Hydrology*, 608, 127615. [https://doi.org/10.1016/0022-1694\(95\)02739-C](https://doi.org/10.1016/0022-1694(95)02739-C)
30. World Meteorological Organization. (2024a). *State of the global climate 2023*. WMO. <https://wmo.int/publication-series/state-of-global-climate-2023>
31. World Meteorological Organization. (2024b). *Bulletin of the WMO* (No. 2224/163). Geneva, Switzerland.

Вплив регіональної зміни клімату на небезпечні гідрометеорологічні явища в Азербайджані

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АНОТАЦІЯ

Спостережувані на даний момент зміни клімату на Землі мають свій вплив на всі регіони. Сучасне потепління більш помітно проявляється в середніх широтах. З часом зміни в просторово-часовій повторюваності небезпечних гідрометеорологічних подій вимагають постійного моніторингу поточного стану гідрометеорологічних елементів. Стаття присвячена впливу глобальної зміни клімату на регіональну зміну клімату в Азербайджані та небезпечним гідрометеорологічним подіям, які вона породжує, з особливим акцентом на річкових водних ресурсах. Коротко проаналізовано глобальну зміну клімату на Землі, а її регіональний вплив на територію Азербайджану досліджено на основі порівняльного аналізу нещодавніх та довгострокових історичних даних спостережень. У дослідженні річні показники кліматичних елементів були отримані за допомогою математичних та статистичних методів. Для моніторингу нещодавніх змін було проведено порівняльний аналіз між стандартними кліматичними значеннями (1961–1990) та відповідними показниками за коротші періоди часу. У дослідженні використано дані спостережень, зібрані з 61 діючої метеорологічної та 84 гідрологічних станцій Національної гідрометеорологічної служби, що працюють на території Азербайджанської Республіки. Набір даних охоплює період 1961–2025 років і включає вимірювання різних гідрометеорологічних елементів. Аналіз показує, що відносно багаторічної кліматичної норми (1961–1990 роки) середньорічне підвищення температури в країні становило 1,1°C за період 1991–2025 років, тоді як за 2007–2025 роки воно досягло 1,3°C. Однак лише у 2025 році це підвищення склало 1,8°C. За зазначені періоди спостерігається постійне зниження як річної кількості опадів, так і річкового стоку. Відбувається значні зміни в режимах річкового стоку, включаючи зменшення обсягів стоку під час весняно-осінніх повеней та висоководних періодів, а також збільшення під час низьководних зимових періодів. Динаміка небезпечних гідрометеорологічних процесів, що спричиняють стихійні лиха в країні, посилюється у зв'язку з регіональною зміною клімату. Водночас наголошується, що отримані емпіричні результати повинні бути використані науковою спільнотою та враховані в різних прикладних та планових проєктах.

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