

# Study of the Greater Caucasus glaciers and forest distribution routes

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**Abstract.** The glaciers of the Caucasus Mountains and their role in water bodies has been investigated in this topic. Changes in glaciers over time on the peaks of the Caucasus mountains Bazarduzu, Shahdag, Bazaryurd and Tufandag were analyzed as well. It has been determined that the role of glaciers in the formation of Gudyalchay and Gusarchay is exclusively important. A significant percentage of water flows into these rivers as a result of melting glaciers. The nature of the forests of the Greater Caucasus has been studied, and the ways of forest expansion have been investigated. The importance of glaciers and forests for nature conservation has been shown.

**Keywords:** Caucasus Mountains, melting glaciers, river basins, forest expansion, nature.

## 1 Introduction

It is known that the world is experiencing a process of global warming. That is why glaciers are melting quickly. As a result, the amount of water in the oceans, seas and rivers increases. Such processes cause climate change. Currently, extensive research is being conducted in the direction of studying glaciers [2]. Such problems as melting glaciers and increasing the amount of water in rivers are being studied [1-4]. Because this problem is expected to become even more urgent in the future. More interesting is the study of glaciers in the mountains. Because, unlike ocean glaciers, glaciers in the mountains melt faster and affect the water level in rivers. Therefore, glaciers in the mountains have been widely studied recently [5-7].

In Azerbaijan, glaciers and perennial snowfields are primarily confined to a very small area located in the highest peaks of the Greater Caucasus Mountains. The main reason for this is the exceptionally high snow line, which reaches approximately 3900 meters in the Eastern Caucasus, particularly in the southeastern part of the Greater Caucasus Mountain system that extends into Azerbaijani territory. The snow line in the Black Sea ranges of the Greater Caucasus (in Abkhazia) is much lower, at only 2800 meters. Therefore, glaciers and perennial snow cover more extensive areas in the western and central parts of this mountainous region. The Southeastern Caucasus glaciers cover 3.62 km<sup>2</sup> at Bazardüzü Peak, 1.0 km<sup>2</sup> at Bazaryurd Peak, 0.51 km<sup>2</sup> at Tufan Peak, and 1.08 km<sup>2</sup> within the Shahdag Massif. The majority of these glaciers (5.64 km<sup>2</sup>) are located in the Gusarchay basin, with an

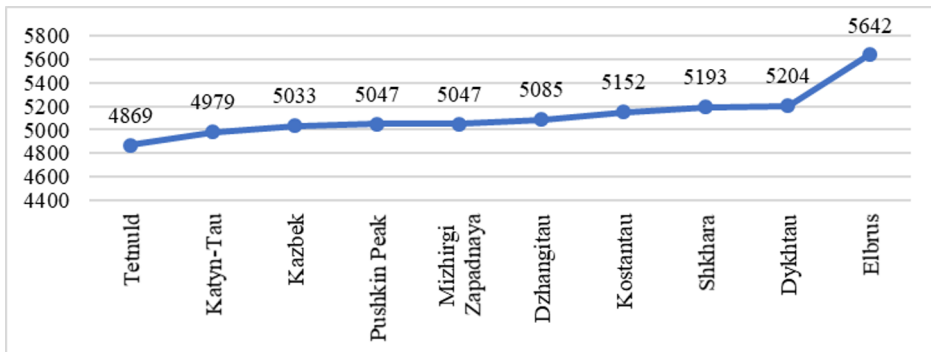
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additional 1.01 km<sup>2</sup> in the Qudyalçay basin. Glaciers make up 0.81% of the Gusarchay basin and 0.13% of the Gudyalchay basin. Despite the relatively small extent of these glaciers, they exert a significant influence on the hydrological regime of the rivers, playing a crucial role in their sustenance. In the Lesser Caucasus, glacial formations are confined to a small area (0.15 km<sup>2</sup>) on the Kaputjugh peak of the Zangezur Range. These glaciers are mainly located in the Okchuchay basin, with a smaller portion situated in the Gilanchay basin. The total area of snowfields above 3900 meters in Azerbaijan’s highest peaks reaches up to 20 km<sup>2</sup>, most of which are concentrated in the high peaks of the Greater Caucasus. The general appearance of the glaciers of the Greater Caucasus is shown in Figure 1.



**Fig. 1.** General view of the glaciers of the Greater Caucasus.



**Fig. 2.** Dynamics of the height of the Caucasus Mountains

In the territory of Azerbaijan, glaciers are located on the northeastern slopes of the Greater Caucasus, specifically within the basin of the Gusarchay River. In the territory of Azerbaijan, glaciers have been preserved on individual peaks and the storage. According to the morphological type, the mountain glaciers of the Republic are divided into two main types:

1. Glaciers of mountain slopes (kar, hanging kar, hanging glaciers)
2. Mountain peak glaciers (flat summit glaciers)

The first type of glaciers is observed on the slopes of peaks such as Bazardüzü, Bazaryurd, Tufan, and others in the Greater Caucasus Range. The second type of glaciers is found on the summit of Shahdag peak of the Yan range.

Bazarduzu Peak is a prominent mountain in the Main Caucasus Range, straddling the border between the Republic of Azerbaijan and Dagestan. Its summit reaches an elevation of 4,466 meters and it is situated within the Gabala district.

## 2 Experimental study of glaciers

The Western Caspian University Sports Club, established in 2005, currently stands out among university sports societies in the country with 150-200 members, and has been maintaining its leadership for many years in the disciplines of sports tourism, orienteering, paragliding, mountaineering, and sport climbing. The club has several mountain sports centers, an artificial wall for sport climbing, a center for climbing routes in natural terrain, and training areas. The club's material and technical inventory is regularly updated and equipped with new tools for the relevant sports disciplines (Figure 3).



**Fig. 3.** Study of the glaciers of the Greater Caucasus.

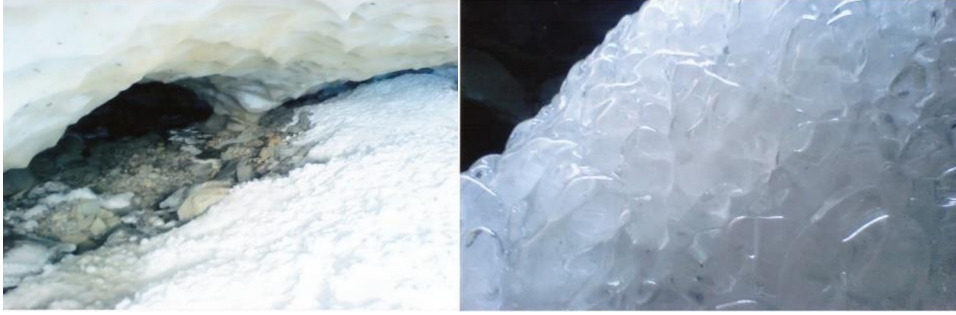
Thanks to our research, it was determined that both the reduction and the melting process in the glacier area are accelerating, the number and size of the cracks on the glacier are increasing, the glacier tongue is retreating every year, and the water level and consumption in the Mahmuddara River, which flows out of the glacier tongue, is increasing. . These observations indicate an intensification of the melting processes within the glacier. The glacier's parameters and coordinates have been determined using GPS and laser rangefinders.intensity of the melting process in the glacier. The parameters and coordinates of the glacier were determined by GPS and laser rangefinder.

In the current year, the club has coordinated both domestic and international mountaineering expeditions, conducted training sessions, organized trekking activities along mountainous routes, hosted skyrunning competitions, facilitated numerous camps, and engaged in mountain tourism festivals.

It is important to note that glaciers not only serve as a fresh water resource but also act as key indicators of global climate change. They are unique objects for visually observing changes occurring on our planet. Climate variations, whether characterized by warming or cooling, are promptly reflected in the fluctuations of glacier extent.

The Tufandag Glacier is located to the north of the Tufan Peak and is considered the largest glacier in the area. Due to the influence of gravitational forces, the glacier is inclined to move northward and often remains in a hanging position.

Over the past decade, a decreasing trend in the water flow of the country's internal and transboundary rivers has been observed. It has been determined that the glacier area has reduced to 2.4 km<sup>2</sup>. Additionally, there has been an increase in both the number and size of crevices on the glacier. This indicates an accelerated intensity of melting processes in glaciers, which is a key indicator of climate change (Figure 4).



**Fig. 4.** Melting glaciers.

A delegation from the International Mountaineering Federation, in partnership with Western Caspian University, climbed the high peaks of the Greater Caucasus. The expedition traversed the routes Guba-Khinalig-Shahyaylag-Bazarduzu and Guba-Khinalig-Ateshgah-Gizilgaya-Heydar Aliyev Peak (Figure 4).

Members of the International Mountaineering Federation, including Jan Malo Claude Alexis, Miczka Jean, Poulain Marie Geraldine Marguerite, and Caraty Celie Lune Marine, participated in the expedition. Additionally, students, staff, and graduates of Western Caspian University took part in the trek to "Heydar Peak" (3,751 meters) within Shahdag National Park. An employee of the University's Sports Club received a letter of appreciation for their role as a guide, aiding in the organization of the march.



**Fig. 5.** Heydar Aliyev Peak.

One of the primary objectives for Western Caspian University in the future is to enhance efforts towards the conservation of mountainous environments, develop recommendations for the preservation of mountain cultures, and designate protection status for endangered mountain cultures. Additionally, the university aims to focus on fostering awareness of mountain culture and mountaineering opportunities, making these topics central to its discussions and initiatives.

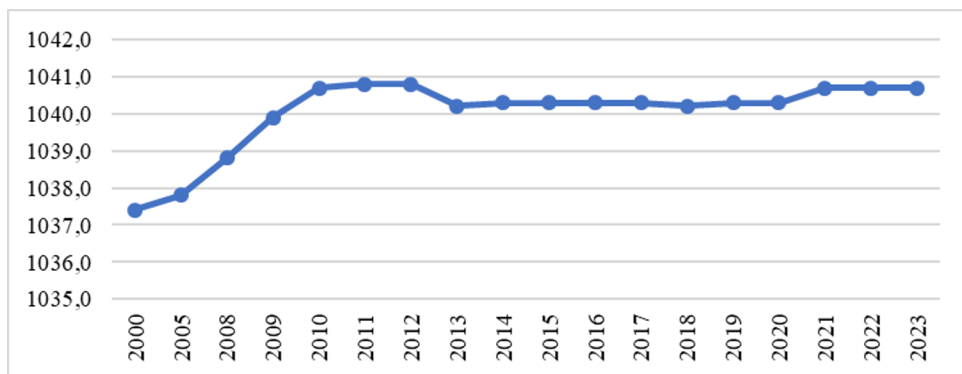
### 3 Experimental study of forests

The Republic of Azerbaijan is classified as a sparsely forested region. Due to the economic problems of the transitional period and armed conflicts, there has been an increased impact of human activities on forests, resulting in both a reduction in forest area and a decline in their quality.

One of the reasons for the unsatisfactory condition of the existing natural forests in the Republic is the insufficient level of natural regeneration. Global climate change, inadequate implementation of forest protection measures, and the increase in pests and diseases have led to a decrease in both the productivity and quality of forest seeds. As a result, natural regeneration in forests is unevenly distributed and is not occurring sufficiently. At the same time, the lack of control over livestock grazing in forests and the uneven natural regeneration process hinder the natural development of young forests. Recently, areas of degraded forests are first converted to shrubs, then often to pastures, and ultimately, typically, to barren wilderness.

One of the most critical issues is the implementation of forest management plans to ensure the protection and preservation of existing forests, establishment of new forests, proper identification of service and sanitation clearings, volume calculations, and the continuous and sustainable use of forest resources. The preparation of forest management plans requires the training of local personnel, the establishment of a training center, and the provision of appropriate equipment as fundamental conditions.

Western Caspian University places significant emphasis on the protection, promotion, and education regarding forests, starting from the family level, through preschools, primary schools, and continuing at higher education institutions. This involves the preparation of educational materials (textbooks, visual aids, display boards, photomontages, etc.), delivering lectures, organizing periodic seminars, enhancing the knowledge of specialists through courses on new scientific achievements, and improving the programs of nature enthusiasts' clubs and centers. The university is committed to organizing school forestry activities as part of ecological education for the younger generation, establishing nature enthusiasts' clubs and centers, and ensuring that the teaching of forestry and nature conservation science is carried out by specialized experts in close collaboration with forest management sectors.



**Fig. 6** Forest areas in Azerbaijan (Source: The State Statistical Committee of the Republic of Azerbaijan).

The primary mission of the "Mountain Biodiversity, Landscape and Culture" Research Institute, established by the University in cooperation with the UIAA, is to enhance the focus on mountain conservation, identify recommendations for the preservation of mountain

cultures, secure the protection status for endangered mountain cultures. The institute focuses on providing opportunities to closely explore topics such as mountain culture and mountaineering prospects.

The institute strives to promote and disseminate high-level research on mountain landscapes by collaborating with various state and non-state agencies, government and non-governmental organizations, as well as local and international institutions. Additionally, the research conducted by “the Mountain Biodiversity, Landscape, and Culture Research Institute” offers insights into the dynamics and prospects of mountain tourism. This work facilitates timely updates for students on recent developments in the field.

One of such initiatives was the creation of a forest belt in the area where the Research Institute's base is located. Specifically, establishing a forest belt at an altitude of 2,600 meters above sea level and planting trees was achieved through significant effort and dedication (Figure 7).



**Fig. 7.** The process of studying the forest.

## 4 Conclusions

Forests and glaciers of the Greater Caucasus have been experimentally studied. During the research, excursions were conducted and the Greater Caucasus was experimentally studied. It was established that the water level in the rivers changes as the glaciers in the mountains melt. It is known that one of the important factors in plant development is water. Reforestation, increasing the number of trees solves a number of problems. Among these problems, environmental problems and air pollution occupy a special place. Therefore, an increase in the water level in the rivers contributes to irrigation processes. However, the rapid melting of glaciers causes other environmental problems. An increase in the level of recycled water causes floods, river spills and forest flooding. The ways to solve these problems are shown.

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