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The Geography of Risks of Breakthrough of Glacial Lakes and Valleys

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ABSTRACT

Against the background of climate warming, various natural events are frequent. One of them is floods, which occur when drowned lakes that are damaged by many factors break through. Such events are common during the advance and retreat of glaciers. The resulting dammed lakes differ from each other in their strength, duration, character and other properties. The result of floods has mostly a negative impact on the surrounding area in the glacier valley. There are examples of both processes in Georgia, and their results are always negative, so their study and some kind of systematization is necessary to properly manage the expected natural event to avoid the catastrophic consequences of overflowing floods.

Key words: *Dam floods, breakthrough, glacier, drowned lake, dammed lake, mudflow.*

Introduction

Many catastrophic events related to climate warming (including in Georgia [1-4]) have become more frequent in the modern world. All of them are sensitive and by their nature represent a threat to the surrounding area as well as to the inhabitants. One of the catastrophic events in the background of climate warming is the action of glaciers, which has been going on for years in the mountainous part of Georgia. Glaciers are characterized by pulsations, during which they periodically advance or retreat. In both cases, the process is noteworthy because of their action, it is possible to create dammed lakes and their sudden breakthrough. Also important are the depressions and breakthroughs on the negative forms on the glaciers, or in the depressions under the tongue. In both cases, defining the perspectives of avoiding the consequences of expected floods is important for the sustainable development of the mountainous part of the country.

Materials and methods

The data are searched and marked according to the multi-year materials, which are given both in the studies of the Institute of Hydrometeorology and in the National Environment Agency. The data of dammed lakes and their morphometric parameters in the individual studies of the authors refer to the breakthrough of dammed lakes and the occurrence of marginal waterfalls. Also, to analyze such processes in the world.

Results

The active reduction of glaciers in the world started in 2006 and continues to this day. In any case, the process of their retreat and advance is dangerous for the breakthrough of glacial dammed lakes. Almost all mountainous countries in the world have similar processes. Their active and modern management is available to most developed countries, because the state structures are actively involved in the implementation of budgetary protection mechanisms. A similar type of engineering is not achievable in developing countries.

Such countries are India, Pakistan, Andean countries. Losses are also recorded in the Cordillera and Alps. The process of melting, which is taking place on the glaciers today, causes the quantitative increase of the glacial lakes. However, it should also be noted that if the warming continues, there will be no more glaciers, which will reduce the risks of events related to frozen lakes in mountainous regions. However, the disappearance of glaciers represents a separate ecological disaster. [5,6] As for Georgia, disasters arising from the breakthrough of glacial lakes have always occurred over the years. Moreover, according to the risks of this disaster, our country ranks 26th in the world (Fig. 1) [5]

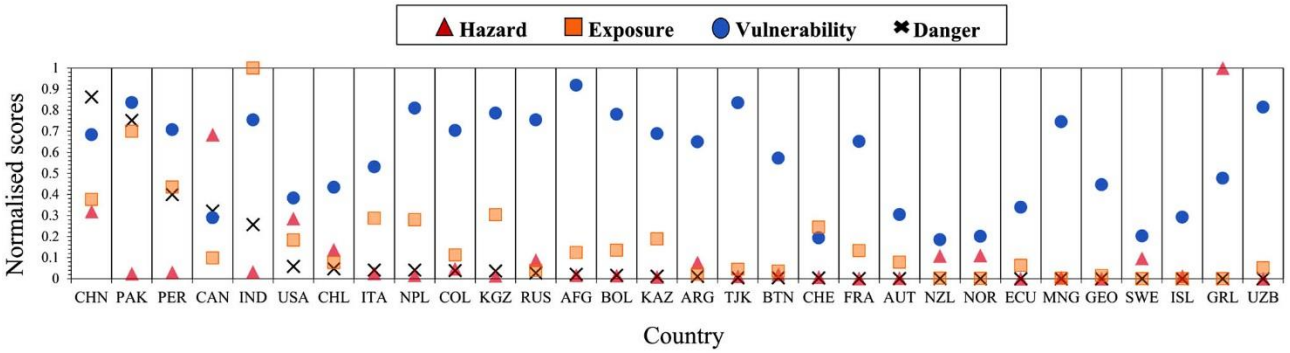

Fig. 1. Final normalised scores of GLOF lake conditions (‘hazard’), exposure, vulnerability, and danger for each country, rdered from highest danger score (left) to lowest (right).

Such examples in history are known under the name of "Kazbeg fall". In the glaciation area of the glacier, pulsation occurred on the Devdorak glacier in 1776, 1785, 1808, 1817, 1832, 1842 and 1854. The glacier advanced catastrophically by 3-5 km. The valley was covered with ice, moraines and gravel. Numerous ice crevasses and subglacial voids appeared. Water accumulated, strengthening the condition of the advancing glacier. There were cases when the process of melting of ice dams lagged the accumulation of water. Water collected in negative landforms; Ice dams were breached due to heavy subsidence, which was followed by waterfalls. The strongest catastrophic flood occurred on August 20, 1832. The rapid waterfall (40-50 m/s) brought down the 15 million m3 volume of debris. who seized the river. Tergi in Dariali valley, village Below Gveleti, 2 km long, 90-100 m thick. The river stopped for 4 hours. pattern flow. Dagubda water: volume 20-25 million m3, depth 80-90 m, the breakthrough of which was followed by a catastrophic flood. During the last policing on Dedvdorak, the same processes were repeated in 2017.

An example from the past is also the glacial bath from the Kazbegi glaciation. Here, at the beginning of June 1909, on the left side of the glacier, Mt. Bagna (4048 m) was cut off by a huge southern slope, which fell in the form of a rock-avalanche at an altitude of 3550-3560 m above the glacial bath, occupying its entire 350-400 m wide surface [7-9]. The 1.82 km long tongue was actually cut off. The stability of the ice bath was broken. A network of fissures of various lengths, depths and widths, intra-ice and sub-ice voids appeared; As a result of the accumulation of water, many small open and closed lakes appeared. On June 6, 1909, the dams were breached as a result of the flooding, which was followed by a glacial flood. river In the Chkheri valley, the village suffered a lot of damage. To Gerget, the military road was cut off. After 2 hours, the dam broke, and the stream of water came down in the form of a waterfall.

An example of the retreat of the glacier is also the natural event that occurred on Mna in 1953, which occurred on the moraine lake of the same name located on the tongue of the glacier. The main factor was atmospheric precipitation (127 mm). during which the glacial dam could not withstand the water; broke through and caused a dam flood. river Mnaskhevi was covered with a 4-5-meter-high embankment of debris from the flood.

Unfortunately, on August 3, 2023, Md. A natural disaster also occurred in Bubisskali valley. When a rock-avalanche broke off to the west of the Buba glacier, which collided with the glacier. According to the research of the National Environmental Agency of the LSI, the rock-avalanche caused the collapse of a certain

part of it, which caused the overflow of subglacial water masses, after which the generated flow began to move at a high speed in the bed of the valley (Fig. 2, 3).

Fig. 2. Buba Glacier and the birthplace of a rock avalanche
Fig. 3. Glacial mudflow in Buba river valley, near Chanchakh river

The dynamic rocky material and part of the glacial mass transformed into a glacial mudflow flood bordering the waterfall in the upper part of the valley. The high-speed flow in the bed, in the middle and lower part of the valley, caused the base of the slopes to be washed away, activating coastal landslides. Unfortunately, 33 people who were in the Shovi resort lost their lives in the disaster. (Fig. 4)

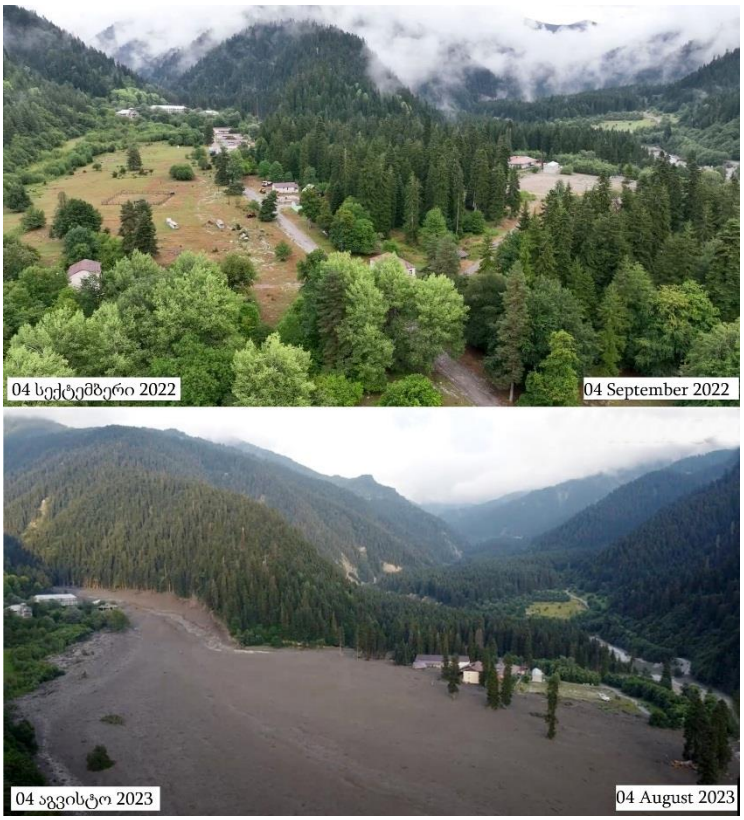

Fig. 4. The photo shows the Shovi resort before the disaster in 2022 and after August 3, 2023.

Based on these examples, when glaciers move back and forth, they leave behind the debris they brought, so-called end moraines. (Fig. 5) Negative landforms also appear, where water collects and forms morainic lakes. That's why it's important to control them. Lakes on glaciers were studied according to

cartographic and remote sensing. Studies have shown that they are widespread in the nival-glacial zone of the Western Caucasus, occupying insignificant areas (from 100 to 10,000 m^2), depth (from 0.5 to 10 m) [10-12].

Fig. 5. A glacial lake on a glacial moraine, southern slope of the mountain Mkinvartsveri (2023)

They are placed at the end of the glacier tongue or directly in the glacier. Their variability is different from year to year, as the retreat and melting of glaciers, as well as atmospheric precipitations change their condition. Therefore, each of them is notable for its morphometric properties. which include: (Table 1)

Table 1. Morphometric Characteristics of Glacial Dammed Lakes

Ordinal Number	Short description of the lakes location	Height of location (in meters)	Height of lake (in meters)	Area (A)		Principal Morphometric Parameters and Coefficient			
				The lenght of the lake (in meters)	Watershed basin	Development Coefficient of Watershed basin K=F/f	Development Coefficient of Shoreline Length c=0,28 l/√f	Streching C_1=l/Ƀ= L^2/f	Compactness C_2 =Ƀ/B

As a result of such processes, the lakes that arise and do not form are potentially dangerous objects for the territory and the population in the mountainous area.

Conclusion

Determination of mitigating aspects of the occurrence of natural hazards and natural hydrometeorological events is one of the important aspects for the state stability of the country. Especially when worldwide efforts are being made to eliminate climate warming. At the 28th UN Climate Change Conference in November 2023, the main issue at the world leaders' summit was global warming, which was held in Dubai, United Arab Emirates. Where the involvement of all states was noted to find new alternative solutions to climate problems in order to protect the natural and public environment. Therefore, it is important to manage hydro-meteorological events, to know the disasters that happened in the territory of our country, both in the past and in the modern period. We need to do their statistics, data recording, methods, forecasting and analysis. It is necessary to perform works that include:

1. Complete study of climatic recorders (materials of the day, month, year);

2. In the event of recurrence of floods, determining their inundation areas, zoning them on geo-informational and general geographic maps, as well as planning and drawing up risk assessment maps;
3. Monitoring, such as expeditionary monitoring on existing hydrological channels, in potentially dangerous valleys, which is possible by organizing a hydrological checkpoint;
4. Control of melting in the glacier tongue and ablation-accumulation zone. In addition, monitoring of the depressions, grottoes, doors, cirques and so-called In the area of glacial lakes.
5. Warning of the population;
6. Design implementation of existing hydro-engineering structures in potentially dangerous areas, including drainage devices, which will periodically empty the glacial lake during the melting of water.
7. An early warning system that determines the critical limit of glacier and river levels; Radar measurements along the glacial valley and its adjacent areas.

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მყინვარებზე არსებული დაგუბებული ტბებისა და ხეობების გარღვევის რისკების გეოგრაფია

ს. გორგიჯანიძე, გ. ჯინჭარაძე. მ. სილაგაძე, ი. ჭინჭარაული

რეზიუმე

კლიმატური დათბობის ფონზე ხშირია სხვადასხვა სტიქიური მოვლენები. ერთერთი მათგანი არის ნაზღვლევი წყალმოვარდნები, რომელთაც ადგილი აქვთ მრავალი ფაქტორის მიერ დაგუბებული ტბების გარღვევის შემთხვევაში. ასეთი მოვლენები ხშირია მყინვარების წინ წამოსვლისა და უკან დახევის დროს. წარმოშობილი დაგუბებული ტბები ერთმანეთისაგან განსხვავდებიან თავიანთი სიძლიერით, ხანგრძლივობით, ხასიათით და სხვა თვისებებით. წყალმოვარდნების შედეგი კი უმეტესად უარყოფითად აისახება მყინვარის ხეობაში მიმდებარე ტერიტორიაზე. საქართველოში ორივე პროცესის მაგალითები არსებეოს და შედეგებიც მუდამ უარყოფითია, ამიტომ მათი შესწავალ და ერთგავრი სისტემაზიაცია აუცილებელია, რადგან მოსალოდნელი სტუიქიური მოვლენა სწორად ვამრთოთ, რათა თავდიან ავიცილოთ ნაზღვლევი წყალმოვარდნების კატასტროფული შედეგები.

საკვანძო სიტყვები: ნაზღვლევი წყალმოვარდნა, გარღვევა, დაგუბებული ტბა, მყინვარი, ღვარცოფი

География рисков прорыва ледниковых озер и долин

С. Горгиджанидзе, Г. Джинчарадзе, М. Силагадзе, И. Чинчараули

Резюме

На фоне климатического потепления часто происходят разные стихийные явления. Завальные паводки, которые имеют место из-за переполнения озер вследствии различных факторов. Такие явления являются частыми во время движения ледников взад и вперед. Возникшие бассейны озер отличаются друг от друга мощностью, продолжительностью и другими характерными свойствами. Следствия завальных паводков отрицательно влияют на прилегающие территории ледниковых ущелий. В Грузии налицо примеры этих процессов и результаты всегда отрицательные. Поэтому, их изучение и систематизация являются обязательными для того, чтобы правильно управлять стихийным бедствием и избежать следствия завальных паводков.

Ключевые слова: Завальные паводки, прорыв, ледник, запруженное озеро.