Natural risks in the Kabardino-Balkar Republic’s landscape zones

A B Uzdenova¹,², F E Kanametova², O O Dakhova², N V Tatarenko², R G Miskarova¹, A S Otarova¹ and Z Zh Gergokova¹

¹ Nature Research High Mountain Geophysical Institute, 2, Lenin str., Nalchik, 360030, Russia
² Kabardino-Balkarian State University named after H. M. Berbekov, 173, Chernyshevsky str., Nalchik, 360004, Russia

Abstract. One of the most serious obstacles of a natural character for the development of recreation and tourism are natural hazards and processes. The high-mountainous part of the republic is especially subject to such processes, where most of the recreational objects are concentrated. Of the entire spectrum of hazardous natural processes, mudflows, avalanches, landslides, karst, subsidence, slides, debris, flood and flooding are the most widespread in the republic. In the mountainous part because of strongly dissected relief with steep slopes and considerable depth of incision of narrow river valleys, avalanches, mudflows, landslides and debris, slides, glacial activities are most active. The flat part and the foothills have their own set of natural hazards, among which floods, flooding, subsidence, soil erosion, and droughts prevail. These areas are often exposed to hailstorms. The entire territory of the Kabardino-Balkar Republic is an area of seismic activity. Spontaneous natural processes and phenomena have the most significant impact on the life of the population of the republic and the functioning of recreational facilities located in the zone of their occurrence. Each demonstration of risks in recreational areas leads to undesirable consequences, from dissatisfaction with rest to death of people and wealth.

1. Introduction

Natural risk is the danger perceived by a subject (person) of a natural process or its anthropogenic counterpart in the implementation of any activity [1].

Hazardous natural processes of both natural and man-made are spontaneous events that unexpectedly demonstrate themselves as powerful destructive forces, usually not controlled by human. All these processes are very different in terms of formation factors, features of demonstrations, duration of flow, which can be from several minutes (avalanches) to several hours (mudflows), days (landslides), months and years (channel and soil erosion). Arising independently, many of these processes and phenomena can interact with each other, enhancing the common effect [2].

The diversity of the natural conditions of the republic determines the level of natural hazards for its individual parts. In winter, avalanche activity is active in mountainous areas, mudflow, landslide, landslide and scree processes, and karst are active in summer time. Here also floods are usually formed, reaching then to the plats.
2. **Statement of the problem**

Destructive spontaneous processes are a serious problem for the recreational development of the territory, the solution of which is connected with the development of rational methods and measures of protection, and also the identification of safe areas for perspective development of building and laying of tourist routes [3].

3. **Materials and methods**

On the basis of cartographic data [4] for all landscape-climatic zones of the Kabardino-Balkar Republic [4], the area of exposure of the territory to various types of natural hazards for farming and living conditions of the population was calculated.

The research was conducted on the map Buslik A.V. from the Atlas of the Kabardino-Balkar Republic. The author divided the territory of the Kabardino-Balkar Republic according to the level of risk of natural hazards into 6 zones:

- high – avalanches, mudflows;
- medium – soil erosion, mudflow, hail, floods;
- low-flood;
- a combination of high and medium levels – mudflows, soil erosion, floods, hail, earthquakes;
- combination of medium and low levels – soil erosion, landslides;
- no risk.

We have carried out a generalization of the map, by combining the zones combining the level of risk with the zone with the average level of risk, since these zones contained the same types of danger (Fig. 1).

![Figure 1](image_url)  
**Figure 1.** Map of natural risks in the landscape-climatic zones of the Kabardino-Balkar Republic
We have calculated the area of various degrees of risk for each landscape-climatic zone with the help of GIS technology (Table 1).

Table 1. The areas of various degrees of risk for landscape-climatic zones

| Landscape-climatic zones | Risk level |
|--------------------------|------------|
|                          | High | Medium | Low | No risk |
| Flat                     | -    | 83     | 17  | -       |
| Piedmont                 | 6    | 92     | -   | 2       |
| Low-mountain             | 3    | 69     | 1   | 27      |
| Mid-mountain             | 8    | 67     | 5   | 20      |
| High-mountain            | 56   | 35     | -   | 10      |

To identify the most favorable landscape-climatic zones according to the level of risk, we used the formula (1)

\[
CP = \sum_{i=0}^{3} i \cdot S_i
\]  

(1)

\( i \) – level of risk
\( S_i \) - the fraction of the area with risk level \( i \) in the zone under consideration.

The sum of points for all categories of risk that threaten the area, characterizes the average level of risk for the territory at all. For the classification of a territory by this indicator, each type of risk was assigned points:

- Score  Risk level
  - 0  No risk
  - 1  Low
  - 2  Medium
  - 3  High

4. Discussion of the results

The research obtained the following data:

- Landscape-climatic zones  Score
  - Flat  1.8
  - Piedmont  2.0
  - Low-mountain  1.5
  - Mid-mountain  1.63
  - High-mountain  2.38

An analysis of natural risks in the Kabardino-Balkar Republic showed that the entire territory of the Republic is subject to various dangerous natural processes.

According to the results of the research, the territory was ranked in descending order of the natural hazards point risk.

**The highest risk** is the high-altitude zone.

Such dangerous natural processes as mudflows and avalanches that take the most disastrous forms are prevalent in the region. Destructive spontaneous processes in the Elbrus region are a serious problem for the recreational development of the territory, the solution of which is connected with the development of rational methods and measures of protection, and also with the identification of safe areas for perspective development of building and laying of tourist routes. In the recreational areas exposed to hazardous natural processes (in the area of Chegetskaya glade, Glade Azau, etc.), a large number of hotel complexes and other recreational facilities are built and are being built, and often with no permits for it [3].
Many of the existing routes and areas and newly created mountain-tourist complexes in the Elbrus region are under threat of dangerous natural processes, and some have already experienced the effects of these phenomena. So, the dangerous snow avalanche processes repeatedly destroyed the recreational complexes on the territory of Elbrus region. All recreational facilities built on Chegetskaya glade for the last 10–15 years are in the zone of avalanche danger [3].

In the valley of the river Adyrsu mudflows destroyed Climbing camp "Stal" and "Molnia". (1940), "Dzhailyk" (1983). In the valley of the river Adylsu by powerful blows of breakthrough mudflows in 1958 and 1959, mountaineering camps «Elbrus» and «Shhelda» were exposed. In 1967 mudflow along the river Kyrtuyk was destroyed and damaged many houses in the village of Verkhnij Baksan. Several times (in 1966, 1967, 1983) under the influence of destructive mud-stone flows village Gubasantisu, many buildings and structures of the Baksan Neutrino Observatory, a highway leading to the Elbrus region was damaged. Less powerful demonstrations of mudflow activity occurred in many areas and caused damage of the main road connecting the lowland regions of the republic with the Elbrus region [7].

On 1.09.2017, a breakthrough of the Bashkar glacier lake occurred in the headwaters of the Adyl Su gorge. The breakthrough was accompanied by serious damage to the Prokhladny-Baksan-Elbrus highway. Alpine camp Adylysu was damaged and the Green Hotel was washed away next to the Bashkar glacier.

Of the 43 mudflow pools river Chegem, three of them - characterized by the volume of removal of more than 500 thousand m3 [6]. Two of them are located in the upper reaches on the left side of the valley, and one - from the starboard, it carries a threat for Bulungu. Mudflows of the Bulungu-Su river, which in the estuary part flows through the outskirts of the village of Bulungu, are especially dangerous. Mudflows here are threatened by the Basil, highway and agricultural land. Less powerful debris flows are less than 500,000 m3, but more than 100,000 m3, it means that the mudflow danger is strong, it threaten the villages of Verkhnij Chegem, Eltyuby, agricultural land, hydraulic structures, and roads.

Piedmont and flat zones are subject of medium risk. The main natural hazards are floods, hail, waterlogging, soil erosion, karst, earthquakes. About 760 km2 of the territory of the Kabardino-Balkar Republic are subject to flooding, where the cities of Prokhladny, Maisky, Terek are located, agricultural lands and objects of the agro-industrial complex are concentrated, and a significant part of the population lives in the republic [3].

Due to the peculiarities of the relief and climatic conditions almost annually in the warm period, the territory of the Kabardino-Balkar Republic is exposed to thunderstorm processes. On average in the republic for a year about 70 days are noted with heavy rains and thunderstorms. These phenomena are most active from the third decade of April to the end of September.

Flooding and the flood caused by them are a great danger. One of the most devastating floods was the June 2002. On the territory of the Kabardino-Balkar Republic, were destroyed 552 and damaged 3276 houses, 80 bridges, 340 km of roads were damaged, gas supply was disrupted in 12 settlements, 5 mudflow trays, 75 km of shore protection structures, 156 km of water lines, 66 water intakes, agricultural crops were destroyed on a large area. The hydrographic network of flood impact is represented in the republic by the Terek River and its tributaries of various orders. Almost the entire territory of the river Terek, that is, about 83 % of the Kabardino-Balkar Republic area. The natural flooding zone with a total area of 760 km2 is confined to the valleys of the Malka, Baksan, Chegem, Nalchik, Cherek and Terek rivers and is characterized by a high groundwater level with a low aeration zone, represented by loam and loamy sand.

In the areas of these natural risks there are sanatoriums, outflows of mineral waters, where a large number of recreants gather.

Low-risk and low-mountain areas are subject to low risk. There is a large area of zones where there is no risk (48 %). The risk is practically absent in the recreational areas of the city of Nalchik, in suburban areas. Also safe are the areas of Aushigersky hot springs and Blue Lakes and the Narzanov Valley in the west of the republic.
The main hazards are soil erosion, hail and floods. Mudflows are widespread in the west of the middle mountain zone. Thus, the mudflow along the Birdalysu river with a maximum recorded volume of more than 500,000 m$^3$, which was destroyed many times from 1909 to 2006, popular resort in the area of mineral springs Gili-su [7].

Table 2. Natural hazards affecting recreational facilities in different years

| Date and time of Emergency Situations | Recreational facility | Brief Description of Emergency Situations |
|--------------------------------------|-----------------------|-------------------------------------------|
| 1940                                 | Climbing camp "Stal" and "Molnia". | In the valley of the Adyrsu river, the "Stal" and "Molnia" climbing camps were destroyed by mudslides. |
| 1958-1959                            | Climbing camps "Elbrus" and "Shhelda". | In the valley of Adylsu, climbing camps "Elbrus" and "Shhelda" were subjected to powerful blows from breakthrough mudflows. |
| 9.01.1987                            | Glade Cheget           | The avalanche blocked the entire Cheget glade, reached the Cheget hotel complex, destroyed the economic buildings, squeezed out the glass in the restaurant building, and the snow wave effect was detected on the upper floors of the hotel |
| 12.01.1987                           | Upper river Baksan (Elbrus region) | A massive avalanche occurred as a result of prolonged intense snowfall. There were snow blockages on the roads, numerous cliffs of communication lines and power lines. Part of the rest in tourist hotels was evacuated |
| 18.02.1998                           | Mountain Cheget        | Snow avalanche. Damaged ski trail. |
| 14.02.2000                           | Elbrus region          | With the ascent of the mountain peak in the upper river, Shkheld in a snow-ice avalanche group of 7 climbers hit. They all died. |
| 17.04.2000                           | Tourist base Chegem    | A snow avalanche between the village of Bulungu and the tourist base "Chegem." Road blocked |
| 19.06.2000                           | Bezengi gorge          | Rockfall. Cherek district, Bezengi gorge. The group of climbers from Samara has suffered |
| 10.02.2004                           | Mount Cheget           | As a result of an avalanche from the slope of Mount Cheget, 7 snowboarders died. |
| 03.03.2005                           | Elbrus region, Terskol | Several avalanches came off, as a result of which the café on the Glade Azau was partially destroyed |
| 11.08.2006                           | Mountain Elbrus. Gil-Su | There was a breakthrough of the adjacent lake Birdjalıran, as a result of which a water-stone mudflow was formed. In the area of the resort Dzhily-Su 50 thousand m$^3$ were deposited. In the resort area in the floodplain of the river pools with mineral water, the foundations of the new bathroom pavilions, a road bridge and a section of the road were destroyed. There were no human victims. |
| 11.02.2007                           | Adyr-Su gorge Chegem waterfall | As a result, avalanches killed 3 people |
| 26.01.2009                           | Elbrus region          | The collapse of the rock. A dammed lake was formed that flooded the area. |
| 1.09.2017                            | Elbrus region          | Breakthrough Lake Bashkar. The breakthrough was accompanied by serious damage to the Prokhladny-Baksan-Elbrus highway. Alpine camp Adylsu was damaged and the |
Green Hotel was washed away at the foot of the Bashkar glacier.

24.03.2018  Glade Cheget  An avalanche came down to the parking lot.

On July 21, 2011, an intensive downpour (54 mm – sediment layer) caused mudflows and a rock block collapse, which led to rupture in several places of the gas pipeline, debris on the road in the section with Nizhny Chegem and v. Khushto-Syrt length of about 3 km and damage of private buildings on the site "Small Waterfalls". There were no casualties [8].

Landslides cause significant direct damage in their area of action, destroying roads, houses and structures, damaging pipelines, telephone and electrical networks, causing agricultural land [9]. The most dangerous are the landslide processes that are developing on the territory of cities. Relocation of significant rock masses as a result of landslides can lead to disastrous consequences and become a natural disaster [10,11]. A total of 140 landslides (landslide sites) have been registered in the Kabardino-Balkar Republic. Most of them are located in the pools of the Chegem, Baksan, Cherek rivers. Three landslides marked in the pool Malka.

Based on the literature data, a table 2 of natural hazards has been created that affected recreational facilities in different years.

The obtained data served as the basis for mapping the distribution of tourist and recreational areas of the Kabardino-Balkar Republic according to the level of danger of natural processes (Fig. 2).

**Figure 2.** The basis for mapping the distribution of tourist and recreational areas of the Kabardino-Balkar Republic according to the level of danger of natural processes

5. **Conclusion**

The events of recent years show that the modern economic development and use of recreational potentially natural hazardous territories in the republic are not focused on the necessary observance of elementary rules and regulations ensuring the protection of people, objects, and territories. In the development of recreational areas, elementary precautions are often not observed - hazardous and potentially dangerous areas are developed or even settled. Most emergencies on the territory of the
Elbrus region, caused by the demonstration of dangerous natural processes and phenomena, occur in areas of active recreational activities and population living.

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