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**LANDSLIDE PROCESSES IN THE AZERBAIJANIAN PART OF THE GREAT CAUCASUS AND FIGHT MEASURES AGAINST THEM
(on the example of the Shamakhi administrative district)****S.A.Tarikhazer**

(Presented by Academician of ANAS R.M. Mammadov)

The zoning the Azerbaijanian part of the Greater Caucasus according to the degree of landslide hazard using a 4-point system carry out in the article. The following landslide formation parameters were clarified: morphometric features of the relief (incline of slope, hypsometry, slope exposure, horizontal and vertical partitioning), high-altitude landscape zones, seismic activity of the territory, lithological composition of the constituent rocks, amount of precipitation, hydrological conditions. On the example of the territory of the Shamakhi administrative region the landslide processes are described, the consequences and damage caused by the influence of slope deformations are characterized. The main measures for landslide protection are considered.

Keywords: Shamakhi district, landslide, anthropogenic factor, landslide protection, damage, risk

Introduction

Considerable damage caused by landslides, as well as the diversity and complexity of the landslide process make the problem of its perception urgent. In recent years, the study of landslides has been widely discussed in the Azerbaijani and foreign scientific literature. Landslides are often characterised by the suddenness and high speed of displacement, sometimes becoming catastrophic. They significantly alter the relief, destroy infrastructure facilities, and can be accompanied by significant material damage and loss of life. The risk from the activation of landslide processes makes it necessary to perform work to identify landslide-prone areas and identify the reasons for the development of landslides in the study area [1].

The regional assessment of the development of landslide processes suggests the possibility of their occurrence and the intensity of their formation, as well as identifying the nature of their impact on economic facilities and the amount of damage inflicted within the territories. The basis for the regional assessment of the development of landslides is special zoning [2]. The results of these studies are widely accepted in the development of territorial planning schemes, in the identification of sites for various designed structures and objects.

In recent years, a number of researchers in various countries have developed new methods of analysis and forecasting of landslide processes of various genesis. Thus, most of the methods for predicting landslide hazards require a comprehensive analysis of a huge amount of factual material, using methods based on GIS technologies has become more common [3, 4, 5, etc.]. With the introduction of GIS technologies, landslide hazard assessment has become possible both in scientific analysis and in the economic assessment of the predicted development of the territory.

The purpose of the article is to consider the damage from landslides on the territory of the Shamakhi administrative region, as well as a description of measures to minimise the consequences of their activation. The problem of the negative impact of landslide processes here has become the most urgent in the last decade in connection with the actively integrated development of the territory for recreation.

Research subject and research methods

Currently, more than 400 settlements with a population of about one million people are located in landslide zones in the Greater Caucasus. Every year, due to landslides, the

economy of the republic suffers from the damaged about AZN 40-50 million. In the Greater Caucasus, landslides are formed in almost all vertical belts but they are most widespread in the middle mountain belt. In the course of the study, a comparative analysis of landslide processes has been carried out based on the materials of B.A. Budagov [6], A.A. Mikayilov [7] and others with the results of data based on the interpretation of coloured SS of 1996, 2000-2018, with a scale of 1: 60,000 and field research. It was revealed that over the past 50 years, the area of the territory subject to landslide processes has increased by 1.5-2 times. For example, the landslide area in the Dvorian village was 13 hectares in 1996, and now it is 19.7 hectares; landslide on the right bank of the Girdymanchay River with an area of 10 hectares increased to 15.1 hectares; on the Aghsuchay River, it increased from 27 to 39.9 hectares, in the Nuran village of Aghsuchay region - increased from 16 to 25.2 hectares. In the Shamakhi region, the area of landslides in the Chabany village increased from 3 to 5.2 hectares, in the Dedegyu-nesh village - from 4 to 6 hectares, in the Sagi-yan village - from 1.4 to 3 hectares. In the Gurbanchi village of the Gobustan region, it increased from 2.5 to 5 hectares, in the Poladli and Jairli villages - from 4.2 to 6 hectares. In Gurjivan and Sangalan villages of the Aghsu region, the landslide area increased from 2.3 to 5 hectares. It was revealed that, at present, the area of landslides in the Guba region is more than 200 hectares and over 100 hectares in the Gusar region, etc. Based on the above-mentioned, favourable lithological conditions contribute to the activation of denudation processes, the exposure of slopes, which causes the emergence of new foci of landslide development. The areas of active landslides are expanding, and the areas affected by these phenomena are increasing. Considering that these geodynamic processes created a great danger for the development of the mountainous territories of the Greater Caucasus, there have been carried out the

zoning of this region according to the degree of landslide hazard according to a 4-point system. At the same time, all parameters of landslide formation were specified, including morphometric features of the relief (steepness of slopes, hypsometry, exposure of slopes, horizontal and vertical dissection), high-altitude landscape zones, seismic activity of the territory, the lithological composition of the constituent rocks, amount of precipitation, hydrological conditions (Fig. 1).

The total area of the study area is 27670 km². The territories with an area of 2401 km² (8.7%) have been classified as a high degree of landslide hazard, where the possibility of landslide coverage is 65-70% of the total area. Such dangerous zones include mid-mountain and low-mountain zones of the Greater Caucasus, in the basins of the Velvelachay, Girdymanchay, Gilgilchay, Atachay, Pirsatchay Rivers, and others. In the territories with moderate landslide hazard, the area of which is 6001 km² (21.6%), the possibility of landslide coverage is 50-65% of the total area. In recent years, landslide processes have especially intensified in the high-mountain zone within the subalpine and alpine geographic complexes of the southern slope of the Greater Caucasus, the interfluvium of the Girdymanchay-Tikanlichay. The reason is a sharp increase in anthropogenic pressure (overgrazing).

Intensive deforestation in the mid-mountain zone of the northeastern slope of the Greater Caucasus also caused the activation of landslides, which led to its assignment as a territory with intensive development of landslide processes, the damage by which can reach 50-60%. In the territories with low landslide hazard, the area of which is 1826 km² (6.6%), the possibility of landslides development accounts for 30-50% of the territory. Areas, where landslide processes are not observed, have an area of 17442 km² (6.6%).

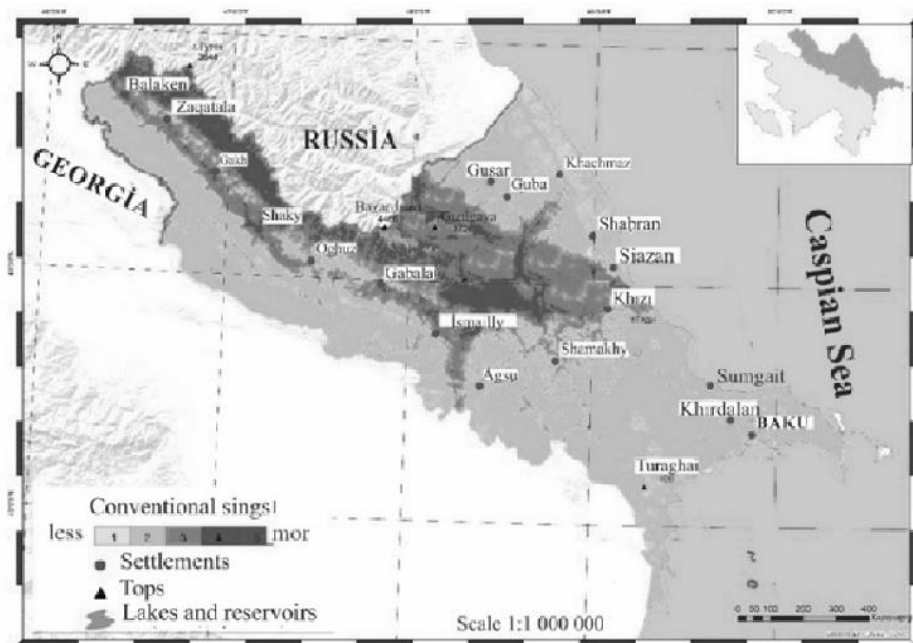


Fig. 1. Map of division into districts of the territory of Greater Caucasus by landslide hazard degree

V points – highly intensive territories with active landslide processes (landslide occurrence probable in 65-70% of the territory);

IV points – intensive territories with active landslide processes (landslide occurrence probable in 50-65% of the territory);

III points – moderately intensive territories with intensive landslide processes (landslide occurrence probable in 30-50% of the territory);

II points – territories with relatively weak landslide processes;

I point – territories without landslide processes.

In the Azerbaijani part of the Greater Caucasus, the territory of the Shamakhi region is one of the territories most prone to landslide processes, where they caused significant economic and social losses.

Within the Shamakhi region, modern relief-forming processes have complex patterns of territorial distribution. For instance, gravitational and erosion-denudation processes prevail in the north, north-west, and the central part; and along with erosion, partly gravitational-denudation processes, arid denudation also prevails in the south-west and south-east parts of the region. Erosion, erosion-gravity-denudation and other exogenous processes are zonal, and arid-denudation processes are azonal, which are especially well manifested in the valley of the Pirsatchay River [8].

Landslides in the Shamakhi region are especially intensive in the basins of the Girdi-

manchay River, in the upper and middle reaches of Aghsuchay and Pirsatchay, on the Govdagh Ridge, in Lahich, on the Nialdagh Ridge, in the Mudri depression, the Baskal cover, etc. If before 2000 landslide processes manifested themselves in several villages of the region - Mughanly, Meysari, and Madras, etc., where 180 houses were subject to landslides, then after 2000, more than 400 houses in only seven villages of the region - Chabany, Madras, Meysari, I-Chayli, Mughanli, Ajidere, and Galeyburg were in an emergency condition. Most of the families were evacuated [9].

In the village of Mughanli, from April 2010 to March 2012, more than 100 houses were destroyed. At present, there are cracks of various sizes in more than 150 houses where 2,400 people live in the Muganly village with 460 farms. Two houses, 100 hectares of land (private plots and arable land, orchards) are

completely destroyed. In addition, landslide processes are widely developed on the highways of the region: in three places of the 3 km-Shamakhi-Pirgulu-Damirchi road, 147-153 km of the Baku-Shamakhi-Aghsu, Gushchu-Alabashli road, 24-25 km and 35-40 km of Shamakhi-Galeybughurd-Kechmeddin, 5-6 and 10 km Chukhuryurd-Gizmeydan-Pirbeyli, 25 km Gushchu-Chayli, in seven places of the 19-20 km-Shamakhi-Goylar-Padarchel, Shamakhi-Mughanly, etc. There are 15 residential buildings in the 48A block in the landslide-prone zone of Shamakhi city. The landslide destroyed one house, a road, and a water supply. Numerous cracks were found in seven houses.

Images from the Google satellite using the ArcGIS software for 2001 and 2018 have been compared, the landslide area have been calculated and the dynamics of the landslide have been identified (Fig. 2). The landslide area in 2001 was 6.74 hectares, while in 2018 - 9.95

hectares. Over 18 years, the area of this landslide has increased 1.5 times.

Over the past 5 years, 140 residential buildings have been completely destroyed in the Shamakhi region in the development zone of 11 landslides. Of these in the Muganly village - 50 houses, in the Sagiyan village - 18, in the Dedegunesh village - 39, in the Chagan-1 village - 7, in the Chagan-2 village - 8 houses, etc. have been destroyed. Numerous houses are located in a landslide-prone area in the Miri, Meyseri, and Chabany villages. The area of landslides developed on 2-11 km of the Shamakhi-Muganli road covers 10 hectares, on 106-110 km of the Baku-Shamakhi road - 5 hectares, in the Chabany village - 5.1 hectares, in the Dedegunesh village - 6.3 hectares, in the Sagiyan village - 3.3 hectares, etc.

Table 1 shows data on damage from landslide processes from 2014 to 2018.

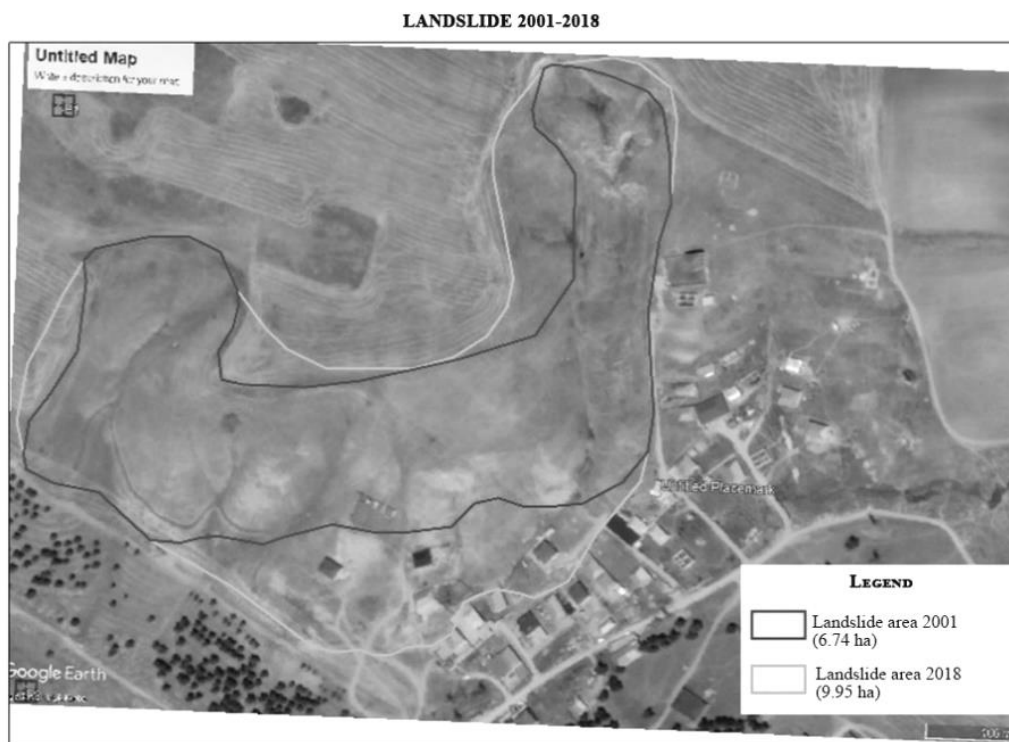


Fig. 2. The dynamics of the development of a landslide in the 48A district of Shamakhi

Table 1

Damage caused by landslide processes for the 2014-2018 period

№	Date	The number of damaged or destroyed objects	Damaged road sections (km)	Settlements and roads
1	27.02.2014	-	147,149,150 и 152 km	Shamakhi-Agsu Road
2	7.03.2014	-	149 and 150 km	Shamakhi-Agsu Road
3	12.11.2015	-	106-109 and 111 km	Baku-Shamakhi Road
4	26.02.2016	-	147 km	Shamakhi-Agsu Road
5	3.06.2016	-	106-107 km	Shamakhi-Agsu Road
6	14.11.2018	1 home	-	Madrassa s.
7	6.12.2016	-	21-22 km	Shamakhi-Gizmaydan Road
8	22.12.2016	1 home	-	Demirchi s.
9	18.01.2017	7 homes	-	Madrassa s.
10	27.01.2017	-	111 km	Baku-Shamakhi Road
11	29.03.2017	1 home	-	Shamakhi c.
12	29.03.2017	-	4,6 and 10 km	Shamakhi-Gizmaydan Road
13	20.04.2017	7 homes	-	Shamakhi c., st. Ashagi Mamedali
14	2.06.2017	-	106-107 km	Baku-Shamakhi Road
15	16.10.2017	5 homes, заборы	-	Sagiyan s.
16	3.04.2018	2 home	-	Shamakhi c., 48A district
17	10.04.2018	3 home	-	Dedegunesh s.
18	12.04.2018	6 homes	-	Adnaly s.
19	19.04.2018	-	106-107 km	Shamakhi-Pirgulu-Demirchi Road
20	24.04.2018	-	3 km	Gushchu-Chayly Road
21	25.04.2018	-	19 и 20 km	Shamakhi-Geylar-Padarchol Road
22	17.05.2018	20 homes	-	Goidan s.
23	11.12.2018	15 homes	-	Gushchu s.

Landslide protection solutions

The design of the entire complex of anti-landslide measures should be based on a detailed analysis of the reasons for the development of the process and the conditions in which it occurs [10]. The main requirements of anti-landslide measures should be: 1) effective; 2) reliable; 3) durable; 4) ensure the manufacturability of the device of protective structures and their operation. By efficiency, it is meant both the economic (feasibility of an event) and technical (the likelihood of ensuring its sustainability during the implementation of measures) issues. A

number of authors [11, 12, etc.] distinguish “active and passive” among the measures to prevent the development of landslide processes. Active measures include the elimination of the main causes of this process, namely the creation of a drainage facility for the removal of groundwater from the landslide mass, regulation of surface runoff due to atmospheric precipitation. Passive measures include the construction of retaining walls of concrete and reinforced concrete. To minimise undesirable consequences in the landslide zone, a special regime is established that could regulate the rules for the pro-

duction of any economic activity, including the operation of various structures.

Results

In mountainous areas, construction of facilities, road construction, etc. are always accompanied by cutting of slopes, which contributes to the formation and activation of landslides. As the anthropogenic load on unstable mountain geo-complexes increases, the geodynamic stresses caused by this load increase. Therefore, it seems necessary to further expand research to identify the nature of the impact of the anthropogenic factor on landslide processes in order to establish not only qualitative but also quantitative characteristics, without which it is impossible to predict the likely consequences of human use of natural resources and develop principles for optimising their use.

To ensure the safety of the functioning of objects in landslide zones, it is necessary to arrange technical protection measures, the main stage of the development of which is risk analysis. This will allow both to minimise possible economic losses from landslides and to optimise the complex of the anti-landslide protection being created. One of the main elements of risk analysis is the assessment of damage from unwanted exposure. It is considered that the review of the damage from landslide processes in the Shamakhi administrative region, carried out in the work, can be used in the future to take administrative measures to minimise landslide risks based on the design (economic and technical) implementation of measures for the technical protection of the study area.

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**BÖYÜK QAFQAZIN AZƏRBAYCAN HİSSƏSİNDƏ SÜRÜŞMƏ PROSESLƏRİ
VƏ ONLARLA MÜBARİZƏ TƏDBİRLƏRİ
(Şamaxı inzibati bölgəsinin təmsalında)**

S.Ə.Tarixazər

Məqalədə Böyük Qafqazın Azərbaycan hissəsinin 4 ballıq sistemə görə sürüşmə təhlükəsinin rayonlaşdırılması aparılmışdır. Sürüşmə əmələ gəlməsinin aşağıdakı parametrləri göstərilmişdir: relyefin morfometrik xüsusiyyətləri (yamacların meyilliyi, hipsometriya, yamacların baxarlığı, üfüqi və şaquli parçalanma), yüksək hündürlükdəki landşaft zonaları, ərazinin seysmik aktivliyi, süxurların litoloji tərkibi, yağıntının miqdarı, hidroloji şərait. Şamaxı inzibati bölgəsi ərazisinin təmsalında sürüşmə prosesləri təsvir olunur, yamac deformasiyalarının təsiri nəticəsində yaranan nəticələr və zərərlər səciyyələndirilir. Sürüşmədən qorunmaq üçün əsas tədbirlər nəzərdən keçirilir.

Açar sözlər: Şamaxı bölgəsi, sürüşmə, antropogen amil, sürüşmədən qorunmaq, zərər, risk

**ОПОЛЗНЕВЫЕ ПРОЦЕССЫ В АЗЕРБАЙДЖАНСКОЙ ЧАСТИ БОЛЬШОГО КАВКАЗА И МЕРЫ
БОРЬБЫ С НИМИ (на примере Шамахинского административного района)**

С.А.Тарихазер

В статье проводится районирование азербайджанской части Большого Кавказа по степени оползневой опасности по 4-балльной системе. Были уточнены следующие параметры оползнеобразования: морфометрические особенности рельефа (уклон склонов, гипсометрия, экспозиция склонов, горизонтальное и вертикальное расчленения), высотные ландшафтные зоны, сейсмоактивность территории, литологический состав слагающих горных пород, количество атмосферных осадков, гидрологические условия. На примере территории Шамахинского административного района описаны оползневые процессы, охарактеризованы последствия и урон, вызванный воздействием склоновых деформаций. Рассмотрены основные мероприятия по противооползневой защите.

Ключевые слова: Шамахинский район, оползень, антропогенный фактор, противооползневая защита, урон, риск