Risks and Threats Emerging Due to Anthropogenic Transformations on the South-Eastern Slope of the Greater Caucasus

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Abstract

The south-eastern slope of the Greater Caucasus Mountains is an area within of Azerbaijan where catastrophic landslips periodically take place. The region is composed of mainly clay, clayey and lime, as well as sandstone. Clayey rocks of Neogene, Paleogene and Cretaceous periods which are considered to be landslip-sensitive. The territory bears risk of landslip whereas the unwise socioeconomic impacts are typically responsible for the intensification of landslips on slopes of the Greater Caucasus. Relevant damage is being experienced by villages and their population as well as highways, communication lines, vegetation areas and pastures. In the past 100 years, Nohurlar, Ahmadyurd, Tirjan, Bakhishli, Khalaj, YukhariFindighan, Tumarkhanli, Alichapan and other settlements were being destructed as a result of landslips while thousands of residents were obliged to settle to other places. As a more evident example, it is remarkable that in 2010 the Mughanli village was seriously destructed as a result of landslip and eventually, the settlement was completely moved to a new place. Landslips, taking place in the mentioned territory due to anthropogenic transformations and also relevant responsible factors were studied with computer programs ArcGis/ArcMap, on the basis of which electronic maps with 1:100000 of scale were created. The landscapes shown in these maps were grouped for the grade of threat.

Keywords: landscape, anthropogenic transformation, landslip, geodynamic, risk, orogenesis

1. Introduction

In recent years, the increasing geodynamic processes as well as social and economic activities in many regions of the world are becoming more and more influential, and this makes necessary to foster conducting of measures on prevention of negative effects of natural destructive processes, and unify efforts in this way. The long-term intensive use of natural landscapes with agricultural and other purposes has led to the transformations of these landscapes at different extent as well as to the disruption of environmental balance of geosystems and the intensification of degradation at the south-eastern slope of the Greater Caucasus. In this regard, the study and management of risk and threats related to anthropogenic transformation of natural complexes is topical issue. Landslips emerge as a result of natural and artificial factors, being responsible for big economic loss, and negatively affecting economic activities. Landslips are particularly typical for mountainous areas where intensive contemporary orogenic processes are observed. These landslips may damage private homes and farms, as well as create serious threat and risk for health of local dwellers. The average demographic loading in areas of natural landscapes makes up 103 persons per 1 sq. km (2011). The corresponding indicator in the territories settled by refugees of the occupied Azerbaijani territories is 132 persons or 3,1 times much more than the average figure. In the last 20 years, the sharp increase of demographic and agricultural loading was responsible for the activation of exodynamic processes as well as landslips.

Large-scale landslips occurring in the south-eastern slope of the Greater Caucasus typically take place in the condition of intensive influence and interrelation of natural and anthropogenic (mainly related to agricultural activity) factors. The enlargement of areas of settlements, meddling in slope geosystems have led to the arising of hotbed of exodynamic processes as well as the rising of risk of landslips. This natural disaster is created also due to unwise consideration and evaluation of lifting capacity of the slopes, unwise territorial organization of water-conducting facilities, and non-proper management of surface flow. The mentioned factors have created a number of small areas of landslip in the condition of different landscape types along roads. Meanwhile, unorganized dispensation of definite municipal lands, and lands of courtyard areas among the population without following of landscape and ecological planning have increased the risk and threat of emerging of landslips in areas of settlement as well.

Currently, 14 active areas of landslips are being observed in only Shamakhi region. As a result of the increasing landslip processes, 156 private houses have faced the high deformation in the region. In winter and spring seasons of 2012, disruption of connection within a few days were observed in the Mughanli area (territory of administrative region of Shamakhi) of the Baku-Shamakhi-Ismayilli highway as a result of landslips which occurred after rainfalls. It should be regretfully noted that the occasion took place because of the weak assessment of related ecological risk and threat. Reconstruction works at highways in the area of Mughanli were conducted at the expense of big financial assistance (Figure 1).

Figure 1: Road Destructed by Landslip (Mughanli-Ismayilli. 2012)

Aghsu Pass, connecting the administrative regions of Shamakhi and Aghsu is a place of high risk and threat of landslip, and therefore is closed for transportation of heavy goods via lorry. The mentioned territory and its adjacent areas are considered to be the first-grade zone in terms of risk and threat of landslip. Human activity is considered to be the main factor in activation of landslips in this territory. These landslips are observed more in those territories of Greater Caucasus where thick layers of clay stone and limestone are placed over widespread layers of clay of Cretaceous and Paleogene period. In regard to motion of mass of soil, delapsive and detrusive landslips are more typical for the Greater Caucasus. In terms of development and covering area, the territorial, linear and frontal landslips can be observed more in the territory. Landslip masses may move along bottoms of valleys. Landslips are observable at all upland areas. However, landslips take place more intensively in medium highlands due to existence of big soil masses on the surface of slopes in the condition of high precipitation. In the areas of lower altitude, landslips take place much less because of low amount of precipitation. In some works, block-form landslips, collapse-form and sliding flows are indicated as the three main forms of landslips (1,3,4). All three types are observable in the research territory.

2. Methodology

Landslips are studied with applying contemporary research methods as well as based on analysis of interconnection of natural components of landscapes and human factors (B.T.San, 2002; P.Kumtepe, 2011; R.P.Gupta, B.C.Joshi, 1990; J.Varner, 1984; L.Gritzer, M.Andrew, R. Appinal, S.Guster, 2001). Latest studies were conducted with using ArcGis/ArcMap programs.

Analysis of landscape features and environmental peculiarities of landslips shows that they are of multi-parameter as they can be influenced by complex of factors, including tectonic activity, lithological composition and incline of rocks, atmospheric precipitations and their distribution on seasons, extent of vegetation and forestation, extent of intensity of processes of erosion and denudation, inclination of a slope, absolute height of an area, social activity and etc. Quantitative and qualitative indicators of these factors were taken into account as a basis for the relevant GIS-study on landslips.

3. Analysis

3.1. The Impact of Tectonic Motions on Arising of Landslips

The territory of research area is known as seismically active zone of 9 points. Tectonic breakings and movement of rock stratums, happening as results of tectonic relocations have lead to disruption and break of horizontal inclines. Further intensive rains and process of intrusion of melting of ices into clefts facilitated arising of landslip more. As B. A. Budagov (1983) indicated, tectonic breakings near the Malkamud, Gazmagiriz, Siyazan and other areas played a role of main catalyzer in the happening of landslips in this zone. The increase of amplitude of height between anticlinal and synclinal areas during tectonic movements made basis of erosion to change. The last process increases possibility of arising of landslip in the territory

3.2. The Impact of Atmospheric Precipitations on Landslips

Although precipitation is gradually increases as higher elevations in the territory, the south-eastern slope sees much less rainfall compared to other slopes of Greater Caucasus. This is connected with the much less inclination of this slope as well as high influence from dry south-eastern and southern winds. Atmospheric precipitations fall at 300-400 mm at 500-600 m of elevation, as well as 400-600 mm at 1000-1200 m of elevation and up to 800 mm at over 1200 m of elevation. In this connection, the intensity of landslips is different on elevations as well. As it is shown in researches (Budagov, 1966, 1983), Attuj, Nohurlar, Yukhari Findighan and Mughanli landslips have emerged just after intensive rainfalls. Lower parts of the low mountainous territory are characterized with weak landslips but high intensity of linear erosion while the higher parts of low mountainous areas and medium altitude belt are the places of intensive landslips (Figure 2). There is a close connection between regime of precipitation and activity of landslip. In the south-eastern slope of Greater Caucasus, rainfalls are observed more in colder period of a year. In this connection, landslips are typically more active in that period.

3.3. The Impact of Cover of Vegetation on Landslips

It is scientifically proved that opportunities for emerging of landslips are much less in those places where cover of vegetation is much dense and extent of forestation is higher. Meanwhile, in some areas, propensity to landslip on a slope may be too higher and therefore, vegetation cannot impede the undesirable process. Landscapes of mountainous field and grassland field are characterized with overgrazing which results in the break of anthropogenic- sensitive vegetation areas, and this process makes erosion processes more intense in the region. Soil fragments emerge due to erosion, and as usual accumulate at valleys of rivers under the influence of gravitation process. Such accumulation on the slopes can be responsible for change of character of surficial flow of rocky materials. The accumulation of materials is influenced by surface waters, and at its ‘critical point’, thick mass of soil begins to move down along slope under the influence of gravity power. Thus, landslips at various speeds occur in the territory.

Figure 2: The Home Destructed by Landslip in Mughanli Village

In the south-eastern slope of Greater Caucasus, the increasing of aridity of climate, the effusive appearance of rocks of clay and in some areas also rocks with salty composition causes to spread of flora peculiar to arid condition. The areas of lower elevation in the south-eastern edge are composed of wormwood, low wormwood shrubberies and other semi-desert flora. The vegetation cover of this area is dense, and make up 40-60% or less. At 700-800 m of elevations and higher areas, the mentioned kinds of plant are replaced by wormwood grove, various grass groves and shrubberies, post-forest xerophyte shrubberies (friganoids), arid forest shrubberies and forests. These plants are characterized as the very sensitive to outside impacts, including human activity. The arid forests and forest shrubs are sustained landscapes in terms of resistance to landslips. Hard and deep roots of these trees and shrubs serve for vertical and horizontal connections among underground rocks. In the past, arid forests and forest shrubberies widespread in the Langabiz Mountainous Range, higher and medium flows of Pirsaat River, basins of the rivers of Giligilchay and Atachay, as well as higher part of the basin of Sumgaitchay River, were playing significant role in preventing of landslips. Later these forests were used as fuel or in construction whereas pasturing activity also was increased. As a result of this, degradation was intensified, and sustained plants were replaced with dry field grasses and bushes with low fertility. Eventually, ecological balance was disrupted at low and medium mountainous belts, whereas exodynamic processes as well as landslips were intensified and more repeated. Conducting of afforestation is notable as an important activity in order to prevent landslips in the area. It is very important to properly choose kinds of trees and bushes for afforestation purpose. Observations show that various kinds of pine-tree are chosen as more preferable in this process whereas in reality, roots of these trees are not sufficiently deeper and therefore are not effective in prevention of landslips. In this regard, it is recommended to plant local kinds of trees and shrubs which are more sustained against dry condition and landslips. Here it is notable that at the end of 2012, in the Badamdar settlement (on the right side of way towards 20th residential area) of Baku city, landslips occured in spite of the existence of pine-trees on the slope which were planted in 60es and 70s of the 20th century.

3.4. Impact of Economic Activity on Landslips

In recent years, the role of anthropogenic factor in emerging of landslips is increasing in south-eastern slope of Greater Caucasus. It relates to the building of modern highways, the creation of tourism and recreation facilities, the extension of territory of settlements, overgrazing, the expansion of vegetation areas, deforestation, etc.

Threat of landslip at the slopes was not taken into account when constructing highways. 2,5 km-part of the Baku-Shamakhi highway at the Jangi depressive area (from Mughanli to Aghsuchay River) is characterized with existence of high risk of landslip. Trucks with heavy loads moving along this direction may cause trembling on surface layers and be responsible also for growth of gravitation loading of layer that may be regarded as artificial earthquake. Eventually, clefts and hesitations can be observed on the asphalt as well. Such situation considerably increases the risk of landslip in this territory during rainy weather. Meanwhile, as practice shows, the implementation of construction works in the territories of local municipalities without taking into consideration landscape and ecological peculiarities of slopes also may led to arising of hearths of exodynamic tension. Such situation are observed in such settlements as Mughanli, Shagiyan, Chaghan-1, Chagahan-2, Miri, Meysar, Jabani, Shirvanzadeh and Hamyali of the Shamakhi administrative region, as well as Arabshalbash, Narimankand, Gurbanchi, Jayirli of the Gobustan region. In addition, the increase of number of tourism and recreation centers in medium mountainous areas is remarkable as a negative factor responsible for increasing of risk of emerging of natural disaster. The organization of rest centers within forest's areas may lead to considerable disruption of circulation of natural humidity and related landslips. Here it is notable that the creation of many rest centers served as one of reasons for the emerging of landslip in Aghsu Pass in 2012. By the way, this landslip is underway. Process of pasturing in agriculture exceeds possible ecological norm in the landscapes of mountainous meadow and meadow field, and this process has been intensifying in recent years. Eventually, soil erosion has been increased in the territory (Figure 3).

Figure 3: A Hearth of Landslip Created Following Grazing at Mountainous Landscape of Meadow Field (Slope at the Right Bank of Pirsaat River, South-East from the Damirchilar village)

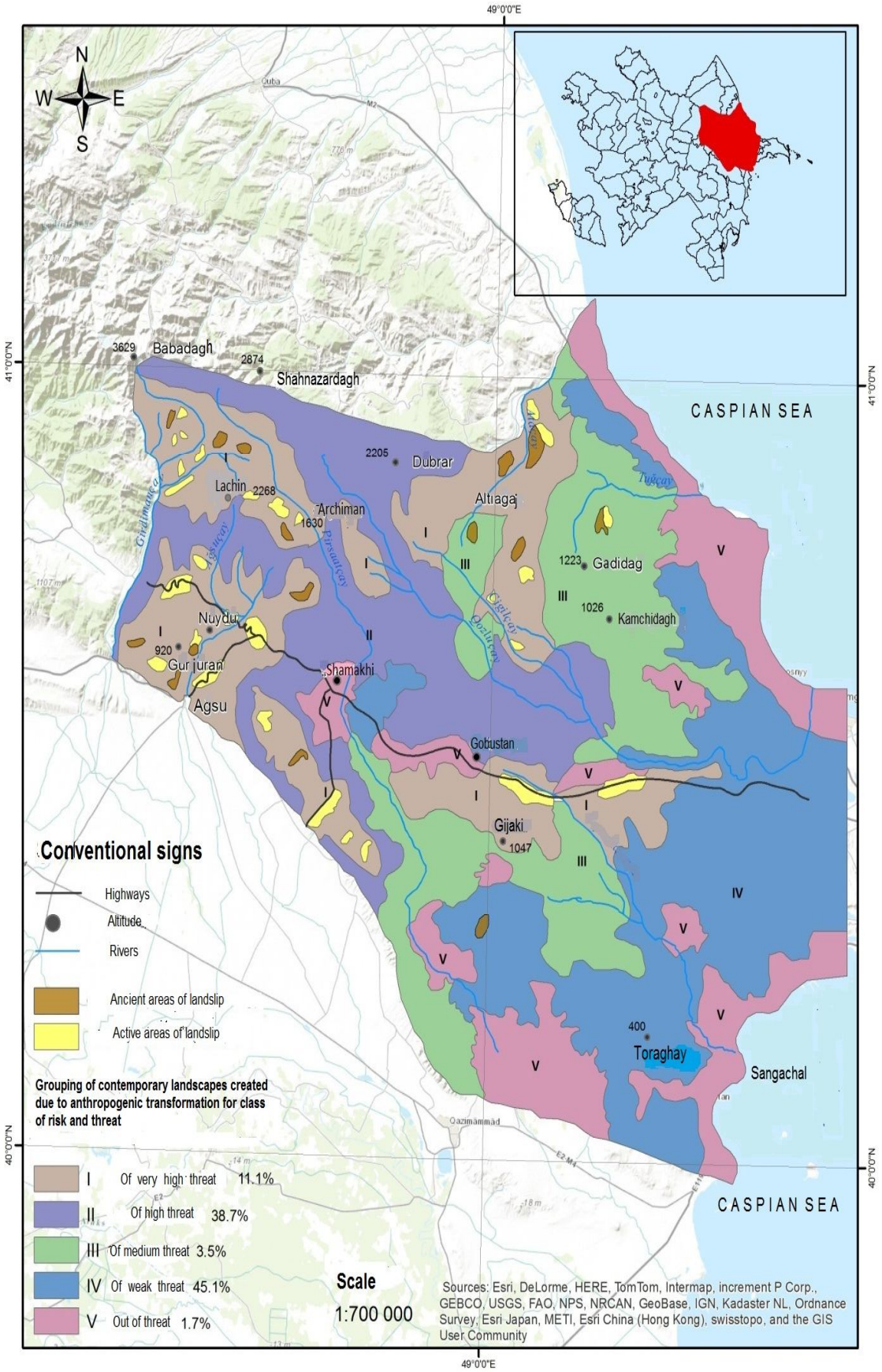

Figure 4: Grouping of Areas of Landslips Created due to Anthropogenic Transformations in Terms of Risk and threat in the South-Eastern Slope of Greater Caucasus

Conclusion

Geosystems in the south-eastern part of Greater Caucasus are grouped for the risk and threat existing due to landslips, taking into consideration transformation of natural landscapes of anthropogenic origin, as well as inclination and direction of slopes, extent of activity of earthquakes and amount of precipitation. This grouping is seen as below: I. Areas of very high threat. II. Areas of high threat. III. Areas of medium threat. IV. Areas of less threat. V. Areas out of threat (Figure 4). Landscapes of I and II classes of threat (high and very high) of landslip are the landscapes of mountainous forest, mountainous meadow, as well as post-forest meadows and shrubberies and field-related xerophyte shrubberies in the basins of such rivers as Girdimanchay, Aghsuchay, Pirsaatchay, Gilgilchay and Atachay. These areas have 8-9 points of seismicity. A series of longitudinal and transverse tectonic breakings increases threat of landslip in the territory. The amount of atmospheric precipitation makes up 600-650 mm to the west, and 400-450 mm to the east. Landscapes with threat of landslip are covering 500-1600 m of elevation. Natural landscapes are highly transformed and have turned to vegetation areas, plantations of fruit and vine, pasture areas, celitebs, places of transport and communication facilities, and tourism centers. 49,85% of the territory falls to share of these landscapes.

Landscapes of third (III) class of threat makes up 1,3% of the overall territory, and encompass eastern part of the territory where low and medium mountainous are spread. Arising of these landscapes is connected with dominance of rocks of clay, clay stone, marl and limestone as well as rocks of conglomerate dated to Neogene and Paleogene periods in the crust of Earth. The seismicity reaches 7-8 points. Anthropogenic factors are responsible for the development of ravine- and gorge erosion which increases risk of landslip. The main landscapes are xerophyte field, dry fields and sparse shrubberies. In some places, density of ravines and gorges are 3-4 times as higher as much compared to ecological norm. The landscapes of this group are used with purpose of pasture, vegetation and vine-growing. Landscapes with low threat of landslip (IV class) make up 33,1% of the territory, and covers low mountainous areas. They include landscapes of mountainous semi-desert and dry field. Precipitation makes up not more than 300-400 mm. The lower amount of precipitation enfeebles intensity of landslip. Grazing is conducted is these areas. The density of ravines and gorges is less while badlands are widespread in the territory. The existence of mud volcanoes in large number are considered as a chief factor in formation of genetics and structure of landscapes. Landscapes with very low risk or safe are covering 3,7% of the territory. They include Pre-Caspian plains, large and flat intermountain depressions, plateaus with smooth surface, plains of high altitude and central parts of flat-form higher plains (Table 1).

Table 1

Row in map	Class of risk and threat of landslip	Territory area, sq. km	Share within overall territory, percent	Intensity of landslip, point
I	Very high	488,3	11,1	1
II	High	1704,2	38,7	2
III	Medium	152,4	3,5	3
IV	Less	1984,7	45,1	4
V	Safe (out of)	73,6	1,7	5
_	Total	4403,2	100,0	_

It seems necessary to carry out complex researches on landscape and ecological peculiarities of south-eastern slopes of Greater Caucasus and other mountainous territories in order to determine landslip hearths as well as eliminate damage that can be made by landslips in the future. Geological and geomorphological processes, climate and hydrological condition, extent of sensitiveness of vegetation cover, structural and functional peculiarities of natural landscapes and the role of human factor should be investigated. Although landslip is a natural process, its activity can be accelerated due to human impact which also can increase risk of emergence of landslip in the areas of relevant threat.

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