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Environmental risk and hazards assessment using GIS technology

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Abstract

In modern science, different innovative methods are often used to achieve the desired results. One of these methods is GIS technology. With this technology you can achieve the right results. In order to assess the level of risk of landslides and hazards, along with the production of appropriate maps with GIS, the development of the territory will be improved and landscape planning will be properly applied. Such maps will help to minimize and eliminate losses caused by landslides that may occur in the future. The causes of landslides are classified in the above-mentioned studies. The first group of causes includes the main causes while the second group takes responsibility for the activation of landslides. The main causes of landslides are morphometric relief parameters, lithological rock composition and soil moisture index, and average constant precipitation and seismicity - activating factors. ArcGIS was used to improve the accuracy and reliability of landslide propagation.

1. Introduction

In recent years, mountain geosystems were under the influence of considerable anthropogenic load, driven by such factors as the rapid development of new settlements, the laying of new asphalted motorways, the construction of industrial facilities as well as the development of mining industry. In this regard, the investigation of landscape- and geomorphological processes, posing a hazard to the sustainable development of the natural-economic systems in the mountainous areas, as well as the forecasting and the prevention of this processes are regarded as topical issues. High seismicity in the south eastern part of the Greater Caucasus favourably affects the occurrence of morpho dynamic processes, including the landslides. The preliminary assessment of hazards and risks posed by landslides in the mountain areas through the application of up-date methods may prevent or reduce damage.

2. Study Area

The study area is situated on the 41°53' north latitude and 49°33' east longitude. The territory area makes up 1057,5 hectares. The area typically has low relief and hilly terrains with the maximum height of 1214 m and the lowest point at 326 m *(Fig. 1).*

Figure 1. *Location of the study area*

3. Methodological approaches

In order to increase the extent of accuracy and reliability of the determination of level of landslide-related risk and hazard, ArcGIS/ArcMap programs and GIS were applied. Landslide risk model based on GIS (Lee,

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2005; Wang et al., 2009; Mora, et al., 1994; Varner, 1984; Griffiths et al., 2008) as well as related investigations (Kumtepe et al., 2011) were used in the work. The assessment and modelling of level of landslide risk and hazard along with the compiling of relevant maps will allow to increase the efficiency of mastering of territory and apply the landscape planning properly. Such maps will contribute to minimize and eliminate losses caused by landslides that may occur in the future.

The GIS-based landslide risk model of (Mora et al., 1994) was used. The reasons of occurrence of landslides are classified in the above mentioned studies. The factors were analysed through GIS in accordance with the following formula:

$$A(fet)_{landslide} = (S_d \times S_{lc} \times S_{sm}) \times (T_{al}+T_{sr}) \quad (1)$$

where S_d is the degree of inclination of slopes; S_{lc} is the lithological composition of rocks; S_{sm} is soil moisture index; T_{al} is the average monthly amount of precipitation in multiyear period; and T_{sr} is the seismicity rate.

R.Kumpete et al. (Kumtepe et al., 2011) used eight indicators to assess the extent of landslide-related hazard: inclination of a slope, direction of a slope, curvature of a slope, index of plant cover, lithological composition of rocks, tectonic fracture, farness in relation to rivers and roads. Landscape- and environmental risks of landslides were identified with taking into account the specific characteristics of the studied south eastern slope of Greater Caucasus as well as such factors as anthropogenic loading, land use, relief, vertical and horizontal fragmentation, indices of landscape's ecomorphological tensity and factors of landscape- and environmental assessment. Relatedly, the following formula was used:

$$S_i = \frac{\sum S}{\sum S_{fic}} : N \quad (2)$$

where S_i is the landslide intensity index; S is the area affected by landslides; S_{fic} is the total area of factors, involved to the comparison; and N is the number of measurements.

The figures of landslide intensity index obtained due to calculations are ranked as follows: <0,1 –very weak; 0,1-0,3 – weak; 0,3-0,5 – middle; 0,6-0,8 – high; >0,8 very high. Researchers note that the correlation between the indicator of landslide intensity index and the level of landslide-related risk and hazard is available. The landslide intensity index was identified by each factor responsible for the activation of landslide. Then the gained data was analysed through GIS. The last phase of was carried out based on the following formula:

$$S_i = \frac{S_a + S_l + S_{vt} + S_i + S_e + S_{si} + S_{sd} + S_{vc} + S_{lc} + S_{tf} + S_{dr} + S_{eb}}{S_{fic}} \quad (3)$$

where S_a is the anthropogenic loading; S_l is the use of lands; S_{vf} is the vertical fragmentation of relief; S_e is the eco-geomorphological tension; S_{si} is the inclination of slope; S_{sd} is the direction of slope; S_{sc} is the curvature of slope; S_{vc} is the vegetation cover; S_{lc} is the lithological composition of the rocks; S_{tf} is the tectonic fracture; S_{dr} is the distance from rivers; S_{dr} is the distance from roads; and S_{eb} is the environmental balance.

4. Results

The use of land as one of forms of anthropogenic activity is regarded as an important factor of assessment of risk and hazard posed by landslide (Ismayilov et al., 2012). Researches show that landslides may happen at very different extent depending on agricultural activities, perennial plant-growing, gardening, pasturing, settlements' impact, the availability of roads and communications, etc. *(Fig. 2)*.

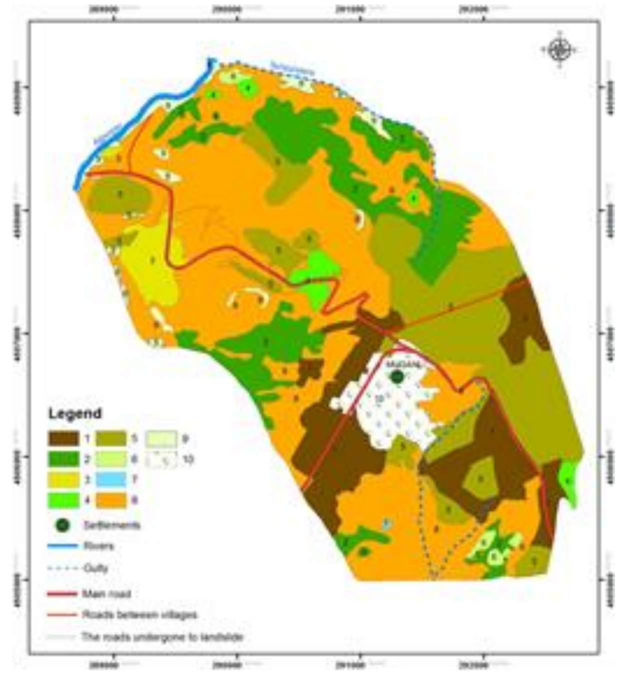

Figure 2. *Impact of soil use on the landslides*

The map legend reflecting the impact of soil use on the occurrence of landslides in the municipality of Mughanli and surrounding areas:

1. Plantations of perennial plant-growing – medium hazard of landslide. 2. Rare trees and shrubs used in pasturing – medium hazard of landslide. 3. Shrubberies and meadows composed of small bushes and used as pastures and hayfields – very high hazard of landslide. 4. Woodlands, partially used in pasturing and anthropogenically degraded – low hazard of landslide. 5. Arable or fallow lands of low-incline watershed areas – very weak hazard of landslide. 6. Fruit gardens, composed of perennial plants – weak hazard of landslide. 7. Artificial water reservoirs – very high hazard of landslide. 8. Pastures and hayfields on low-incline slopes – high hazard of landslide. 9. Cliffs and sandy areas, not usable in agriculture – very low hazard of landslide. 10. Rebuilt settlements, courtyards and roads – very high hazard of landslide.

In order to increase the extent of accuracy and confidence of spread of landslides, ArcGIS program was applied. Furthermore, the relations between the land use and the intensity of landslides as well as related risks and hazards were studied and given on *Table 1.* Results of environmental risks and hazards are grouped as reflected on Table 3. Analysis of this table shows that 55,9% of the territory is of high and very high hazard of sliding.

Table 1. The relations between land use and risks, hazards and intensity of landslides in the study area

Land use form	Contours	Area, km^2	Areas affected by landslide, km^2	Intensity index of landslide	Risk of landslide by point
1	5	1362	409	0,3-0,5	3
2	9	1372	412	0,3-0,5	3
3	2	282	169	0,6-0,8	4
4	5	185	19	0,1-0,3	1
5	12	2155	216	0,1 and lesser	1
6	4	7139	7139	0,1 and lesser	2
7	1	4891	391	0,8 and higher	5
8	5	4455	356	0,6-0,8	5
9	17	2239	223	0,3-0,5	4
10	1	460	368	0,8 and higher	5

Table 2. Distribution of vegetation coverage according to risk and hazard intensity indexes of landslide areas

Number of plant group on the map	Area, km^2	Intensity index of landslide	Risk of landslide by point
1	1082	0,1-0,3	2
2	2583	0,1 and lesser	1
3	46	0,1 and lesser	1
4	3964	0,6-0,8	4
5	681	0,3-0,5	3
6	998	0,6-0,8	4
7	178	0,8 and higher	5
8	151	0,8 and higher	5
9	948	0,6-0,8	4

5. Conclusion

1. The research model, used during this study will allow modelling and assess landscape- and environmental risks and hazards, posed by landslides in young seismic mountain areas of Azerbaijan as well as other young mountain geosystems, shaped during the Alpine folding period. The used model enables to carry out this research as well as similar works in a shorter time based on decipherment of satellite images.

2. Beside with this, the landscape- and environmental balance of the area was studied. Over related 16 factors were involved in the study. As a result of this, the extent of accuracy and reliability, as well as the possibility of application of the carried out research were increased.

3. The obtained results allow to assess risks and hazards, posed by landslides in the Greater and Lesser Caucasus, as well as Talysh Mountains and mountain areas of Nakhchivan. These results can be used in the implementation of the future regional development programs, landscape planning and also the organization of transport infrastructure in the southeastern part of the Greater Caucasus.

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