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Landslide in Kosovo and Necessity for Their Monitoring

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Abstract
Sliding of the land masses in Kosovo is not a new occurrence. Landslide, represent a movement of earth mass under the influence of gravity, as well as caused by human activity. Its emergence in an urban or rural environment is often manifested with direct and indirect consequences on: people, infrastructure, economy, etc. At the country level, there is not any monitoring of landslides. The aim of this paper is to emphasize the necessity of their monitoring.

Keywords: Kosovo, sliding, mass, monitoring, necessity

INTRODUCTION

In recent years, a large number of landslides have been activated in Kosovo. Landslides are one of the most damaging and important geo-hazards in the Republic of Kosovo. They represent a physical movement of land mass without flip under the action of gravity force. Landslide is a general term for gravitational movements of rock or soil down a slope as a mass along discrete shear surfaces [1,2]. They usually arise on slopes filled with water, can also be fostered by earthquakes, volcanic activities, changes in the depths of the earth, groundwater activity, changes from human activities, and the combination of these factors. The emergence of a landslide in an urban or rural environment can cause direct or indirect damage to people's lives, infrastructure as well as other economic damage. It is significant importanceto identify, record, monitor and put the slides under control. This process is carried out to determine if they need to be repaired or not. So far are identified about 40landslides in the territory of Kosovo. They cover an area of 48 km² which represents 0.44% of Kosovo territory. Based on the depth they belong to the group with a depth of up to 5 m, rarely up to 20m. Landslides have endangered the lives of residents, houses, escalators, road infrastructure (and water supply, sewage, etc.). So far there is no monitoring system and official data regarding damages caused by landslides.

The Republic of Kosovo is located in the southeastern part of Europe, central part of the Balkan Peninnsula. It lies in the northern geographic amplitude of 41°50′ 58″ to 42°15′ 42″, and eastern geographic longitude of 20°01′02″ up to 21°48′02″. It has an area of 10.905.25 km², with 1.798.506 inhabitants (ASK, 2018). The highest altitude is 2656 m, while the lowestis 273.5 m (PHK, 2010-2020+). The climate is continental and mountain medallions [3]. The average winter temperatures fluctuate from 0.5 to +0.5 ºC, while in the summer they fluctuate from 21.5 to 22.8 ºC [4]. Average annual rainfall ranged from 650 mm (flat areas) to over 1000 mm (mountainous area) [5].

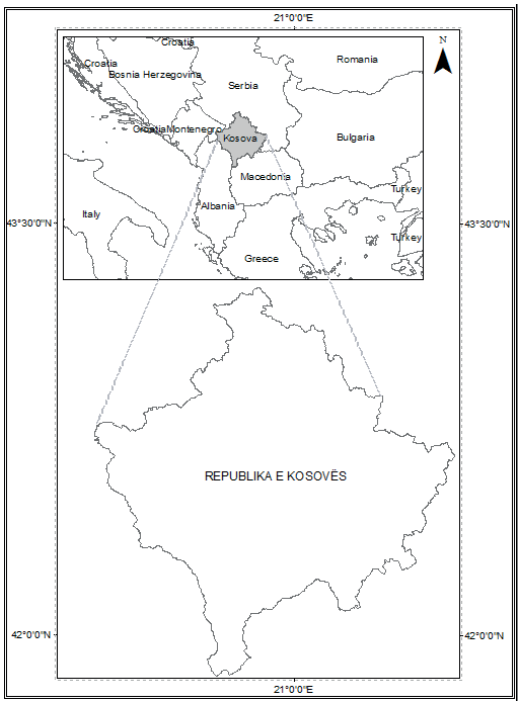

Fig. 1. The location of the study area

The geological seting-study area characterized by a variety of geological formations. Rocks age ranges from Proterozoic to Quaternary. Paleozoic periods are represented by schist, phyllite, schist albit-sericitic, quartzite, sandstone, conglomerates and so on. Mesozoic formations are limestone, marl, clastic rocks, flysch, sand-silty, diabase, serpentinite, sandstoneetc. Neogene formations are represented by clay, marl, sandstone, conglomerates, tufa, coal, sand, gravel and so on. Quaternary formations are represented by sand, gravel, sand, clay, silt and so on.

MATERIALS AND METHODS

The methodology applied in this paper is based on field activities and applied research and practical professional experience. The implementation of the work has been carried out in several phases:

- Field research and data collection-It aimed at identifying, zoning in order to develop preconditions for planning to establish a network of monitoring and controlling them. Through working on the terrain, the coordinates and altitude of landslides were highlighted and in some locations the definition of the surface caught by the sliding was made. GPS coordinates of the Garmin type are used to measure the coordinates.

- Processing, synthesis and data analysis as well the elaboration, synthesis and analysis intended to determine factors and other elements that have led to the formation of landslides.

- Interpretation of results-the interpretation of the results was supported by the collection, processing, synthesis and analysis of the data.

- Writing the paper;

Materials

- Archival data and early studies.

- Data and information from projects made regarding slides.

- Data from field observations.

- Data from literature.

- GPS, program Excel and GIS-ArcMap were used for elaboration and interpretation of these data.

RESULTS AND DISCUSSION

Monitoring of landslides plays an important role in the sense of the sliding process, which is particularly important in urban environments where activating landslides can directly or indirectly endanger people's lives and cause material damage. Although there is no monitoring network for landslides in the territory of Kosovo, field investigative work revealed that the most important factors influencing slippage are:

- Increased inclination of the slope.
- Variation of the groundwater level.
- Loss or decrease of slope stability.
- Excess of load-loading of the slope.
- Anthropogenic activity.

From the historical data it results that in the territory of Kosovo were located 14 unstable areas, potential for the occurrence of slips, crevices, erosion, etc [6].The areas involved by the slides were mapped in the Sitnicë river basin, in Çiçavica mountain sloping parts, throughout in the Prishtinë region, Klinë, Pejë, in the lower parts of the Mokna and Sharr mountains and other locations (Fig.2.).

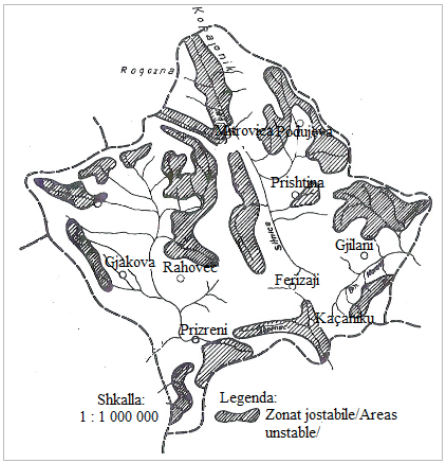

Fig.2. Map of historicaly data of landslides

Based on the data collected from 2006 to 2017 in the territory of Kosovo were identified/recorded a total of 40 sliding areas (Fig.3.). The total sliding area is about 48 km² and represents 0.44% of the territory of Kosovo.The average height of the slides is 657 m above sea level.

Fig.3. Map the spread of landslides in the territory of Kosovo

The occurrence of landslides by years-the data analyzed showed that landslides in the territory of the Republic of Kosovo were mostly pronounced in 2015 (Table 1 and Fig.4.).

Table 1. The occurrence of landslides by years

Year	Cases	[%] Percentage
2006	4	10,8
2010	2	5,4
2013	1	2,7
2014	1	2,7
2015	17	45,9
2016	9	24,3
2017	3	8,1

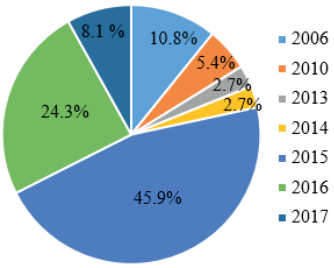

Fig.4. Percentage of landslides by years

The regional spread of landslides-from processing and analysis of results has shown that the largest number of landslides, respectively 23.1%, are recorded in the Prizren region, then in Peja, as shown in the Table.2. and Fig .5).

Table 2. Spread of landslides by region

Region	Nr.of. Locations	[%] Percentage
Prishtina	6	15.38
Mitrovica	4	10.26
Peja	8	20.51
Prizreni	9	23.08
Ferizaji	5	12.82
Gjilani	3	7.69
Gjakova	4	10.26

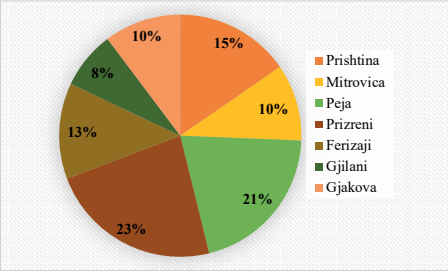

Fig.5. Spread of landslides by percentage

After processing and analyzing the results it was concluded that the largest percentage of the slides in the road segments, have mainly occurred on the territory of the municipality of Prishtinë with 30.56%, and the second territory affected by the landslidesis the municipality of Malishevë with 11.11% (see Table 3. and Fig.6.).

Table 3. Spread of landslides by municipality

Nr. Casses	Municipality	Participation in [%]
2	Drenas	5.56
2	Dragash	5.56
1	Ferizaj	2.78
2	Gjakovë	5.56
1	Kaçanik	2.78
1	Klinë	2.78
1	Leposaviq	2.78
4	Malishevë	11.11
3	Mitrovicë	8.33
11	Prishtinë	30.56
2	Prizren	5.56
1	Pejë	2.78
1	Suharekë	2.78
3	Zubin Potok	8.33
1	Zveçan	2.78

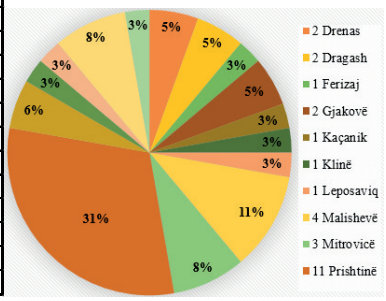

Fig.6. Spread of landslides by percentage

The results in Table 4., and Fig. 7. showed that the largest number of slides that occurred in the back of 2006 and so far, are the segments of the highways.

Table 4. Participation in% of slides according tothe ranking of the road

Nr. cases	Range of road	Participation in [%]
20	Highways	55.6
12	Regional	33.3
4	Motorway	11.1

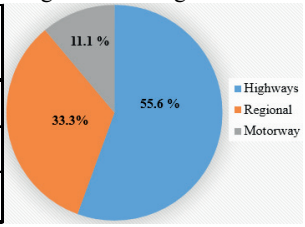

Fig.7. Percentage by range of road

Roads elements affected by sliding-processing and analysis of the results showed that the biggest negative effect in percent was presented in the road element; cuttings with 64.7%, then filling (see table5, respectively Fig.8.)

Table 5. The affected element of rouds from land sliding

Nr.of. Cases	The affected element of road	[%] Percentage
2	Filling	11.8
11	Cutting	64.7
1	Protective wall	5.9
3	Falling of rock or earth masses	17.6

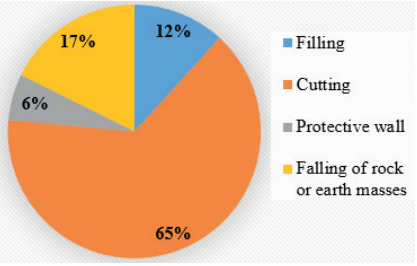

Fig.8. The effected percentage by elements of the range of road

Consequences of slips-the results evidenced that the biggest losses caused by landslides in the period 2006-2017 were in blocking roads by 40.7%, damage to homes by 29.6%, etc., (see Table.6 and Fig.9).

Table 6. Consequences of slips

Consequences of slips	Number of cases	[%] Percentage
Deployment of houses from sliding areas	1	3,7
Road blocking	11	40,7
Demolition of houses	2	7,4
Hazard of houses	8	29,6
Damage to roads	4	14,8
Damage to the defensive walls of the rivers	1	3,7

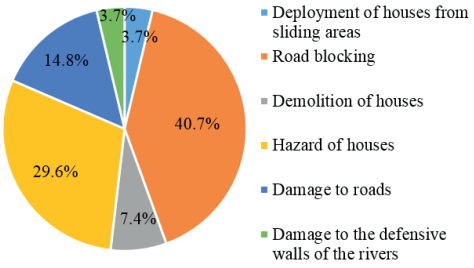

Fig.9. Consequences of slips in different objects

Photo:Landslides on the locality Budakova-Suhareka

CONCLUSIONS

Based on the data and the results which were achieved through this work it turns out that the slides in the territory of Kosovo are quite active, which in most cases pose a risk and adverse effects on human beings and infrastructure.

Landslide are present throughout the country. The risk from them is permanent and the reparation is highly expensive. The largest number of slides are shown at altitude 650 m above sea level. The factors that have affected the landslide and rock mass swing are mostly exorbitant. Depending on the depth they belong to the group with a depth of up to 5 m, rarely up to 20m.The highest number of landslides have occurred in 2015, and are at a large extent evident in the prizren region. Wheareas the largest number of slides appear to bepresent in the road segments, particularly in the administrative territory of the municipality of prishtina. The most affected roads from landslides have been present in the segments where the road has been cut by 64.7%. However the large scale of damage has been caused by the blocking of road segments and destroying residential homes.

Capacity building concerned with methods and their application for assessment and monitoring of slides.

Unique and standardized landslide registration including the following procedures:

- each location is a single point in space, and has defined coordinates or each sliding is a closed polygon.
- aassessment of the basic elements of the phenomenon: type of material (rock, earth, soil), water content, activity, movement velocity, movement, trends, dimensions, threats.
- photo documentation (photographing phenomenon elements and details, such as damaged objects and infrastructure with the appropriate ratio).
- Construction of landscaping cadaster.
- Build a Sliding Map-Map of Risk.

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