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LANDSLIDES IN BUDA (STEMNIC) CATCHMENT

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Abstract. Landslides are part of the gravity action processes, constituting one of the major hazards that can cause material and human damages. The research of these processes implies complex analysis, which includes factors that must be systematically analyzed. The presence of the sloping terrain constitutes the main factor of the action of gravity force. The morphometric indices, including the relief energy, slope inclination and their length have a substantial contribution in maintaining a favorable energetic potential in mass movement deployment processes. Means of computerized analysis are useful in the analysis of the processes, such a method to mapping and identification of landslides is considered to be Geographic Informational Systems (GIS).

Keywords: *landslide, GIS, distribution, Buda Stream (Stemnic*)

1. Geography and overview of the basin

The studied region is located on the East side of Romania, on the southern part of the physical-geographical unit of Central Moldavian Plateau. (Figure1). Buda stream is a tributary of Bârlad River and it's located in the upper right side of the river. The boundaries of the water catchment area are set by the watersheds that are defining the other water catchment areas. The north-east limit of the basin overlaps the water catchment area that defines the area of the main course of Barlad River. On west, were is considered to be the starting point of the stream, is located the watershed that delimits the area in question by Racova River, watershed that continues in the south of the basin till the contact with Barlad riverside. Within these boundaries, the surface of the water catchment area is 150 square meters.

From tectonic and structural point of view, Buda stream basin corresponds to a small extent with the Moldavian Platform. It is a vorland unity with a typical platform structure. In its composition can be distinguished a pleated bottom floor that constitutes the socket and a structural flood, the coverlet, which corresponds to a stage in which the space has evolved as a stabilized area. About the surface geology deposits, between the main factors involved in the genesis of the landslides can be mentioned the presence of some basarabian deposits, Khersonian, Meotian and recent deposits (Quaternary age).

The Khersonian deposits are the ones that mostly dominate the surface of the basin, being mainly represented by a sequence of sands, sandy clays, and marl clays with thin intercalations of calcareous marls. The Basarabian occupies a smaller surface within the basin and as deposits it comprises Repedea-Scheia sand-marl that includes thin intercalations of oolitics sandstone.

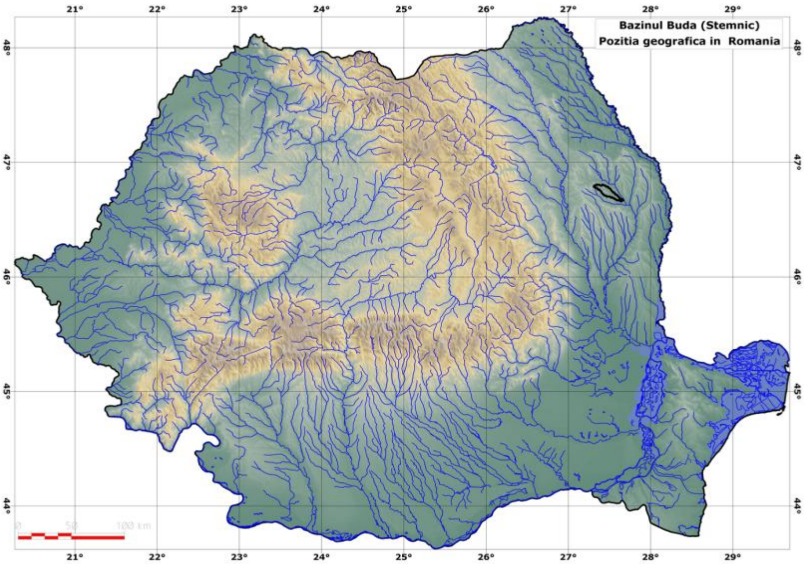

Figure 1 Geographical position of Buda (Stemnic) water catchment within Romanian area

The Meotian occupies the lower surface and is the top of the sediment stack that marks the limits towards Racova water catchment area. Lithologic such deposits contain packages of andesitic sands with sand intercalations, marls and clays, known as "Nutasca-Ruseni cinerites". Quaternary age deposits are the most recent and are being represented by alluvial planes and terraces, eluvial alteration deposits, deluvial or accumulative aprons. (Fig. 2)

Within the analyzed water catchment area the relief represents an assembly of large set of inter-looking bridges, hills and mounds separated by broad valleys, carved in the sedimentary monoclinal of the coverlet. The general surface of the relief, as each of the interfluves, slides down to south-south east, oriented the same as the valleys showing an obvious approach to the structure. The average altitude is about 250 meters which corresponds mostly to Barlad Plateau. Drainage density ranges 700 and 900 $m/km^{2.}$

Mean energy of the relief is 125 m, and slope is generally small, predominant bellow 10^o. Only slopes with intercalations of sandstone, limestone or andesitic cinerites, on Cuesta, the detachment along steep slopes have $15 – 20^o$, sometimes even more. (Romanian Geography,1992). The general appearance of the landscape stands out in many forms due to the presence of horizons monocline structure more resistant to erosion. As a result, structural plateaus and cuestas are the main feature of the landscape.

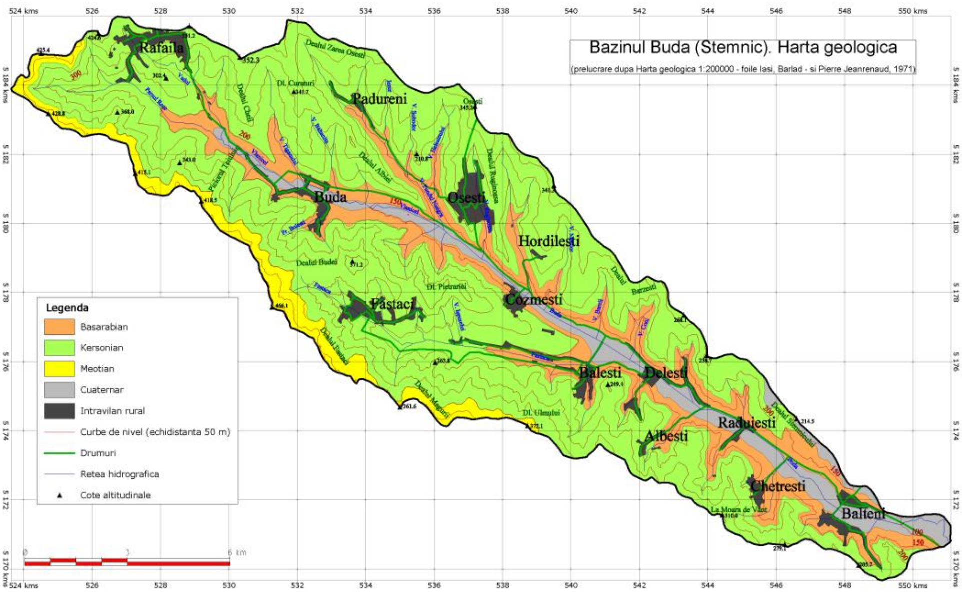

Figure 2 Buda (Stemnic) catchment. Geological map

2. Materials and methods

Information sources for this study were the topographic maps on 1:25.000 scale, geological maps 1:200.000, and precipitation distribution map 1: 500.000 (Climatology Atlas of Romania) and land use map (Corine Land Cover). The database was processed with TNT Mips 6.9 soft.

Under this methodology, the first step was the importation of topographic maps, initially scanned at a resolution of 300 dpi, after which they were georeferenced in the Gauss Kruger – coordinate system having as reference ellipsoid the Krassovski 1938-1940 ellipsoid. The obtained files were divided automatically based on georeference points, to have a topographic database in one file. Starting from this basic information a vector layer of contour points was made which has the georeference points transferred implicitly on digital topographic support. Based on these information it was made a morphometric analysis of the region, using digital terrain model (DTM). This continuous raster representation of the altitude is highly useful, enabling full automatic performance of an amount of operations like generation of gradients and slopes. Subsequently, from the topographic maps were extracted areas with landslides, but without being made any difference between the active or stabile stage of these.

3. Results and discussions

Analyzing the geological map and by doing the association with the distribution of sliding bodies from the basin surface, landslides are present on most of the slopes with high inclination, their development being driven by the prevailing facies of Khersonian and basarabian with clay and sand-clay deposits. The important role of triggers in sliding is based on:

- *presence of plastic materials (clay – marl substrate)*
- *massive infiltration of water*
- *incision of slopes by massive ravines*

In addition to the mentioned causes, it contributes as well human activities by reducing the binding areas of deep root systems of trees, overgrazing of the slopes which create paths for cattle and it helps infiltration or execution of roads in the slope that removed some of the deluvial material.

Most of the landslides are stabilized or semistabilized, but there are several instable. Superficial landslides are presented in form of waves or small monticules that appear on the slopes being caused by freeze-thaw process and that are called solifluxiones. The most common active slides are the ones of small dimensions that have thin deluvials. The large scale sliding grafted onto big sliding deluvials are found in areas with clay, rock-marl interspersed with sand, limestone or sandstone.

Regarding the classification of the landslides, these are approached by many works but most of them are using the geological criteria and their morphology.

Taking into account the morphology of sliding for the studied area there are obvious the following types of sliding:

- monticulare sliding are spread within the water catching area on slopes with clay deposits-Sarmatian clayey and silty Quaternary terrace or deluvials. The sliding micro relief of the diluvium is represented by monticules with circular contour opposed to close the upstream small depressions called bulhacs that contain water from precipitation or from groundwater layer. (Fig. 3);
- step sliding are meet on slopes with rock stratification of different hardness with aspect of pseudoterraces or on silty deluvials with sand-silty substrate. (Fig. 4);
- ‘pit’ sliding type is being formed at the bottom of some torrential valleys with semicircular reception basins, bounded by a cornice well individualized. (Fig. 5);

In Buda basin, based on topographic maps 1:25.000 and on orthophotoplans 1: 5.000, were identified 57 active and semi active sliding bodies with reactivation potential of which total surface is 1278,60 ha. Sliding terrain approach from water catchment area of Buda considers the analysis of causality factors for slopes susceptibility determination that triggers these processes and geomorphological associated risk. Geological conditions play an important role in triggering the associated processes and other causes. About the geology of the surface deposits, that have an important role in genesis of sliding, it can be said that the presence of some Khersonian deposits that dominate as a share in the pool area (69,554 %) being represented through intercalation of clay, sandy clay, and sand, with few hard intercalations, these formations are concentrating most of the sliding bodies. To these ones it adds up a specific morphometry (higher altitudes, pronounced fragmentation).

Basarabian formations are characterized by the presence of some psamitic deposits and subordinate pelite. It has a restrained area within the basin (18,151%) and combines less sliding bodies compared with Khersonian ones, being driven as well by a reduction of favorable indices morphometry. Meotian (5,206%) has the most restrained presence being encountered on interfluves, where the sliding cannot be triggered. The Quaternary, developed along the rivers, it is not an area of terrain sliding within the water catchment area. The relief it is an important factor in landslides trigger, interfering through a multitude of factors. The altitude is an important factor in controlling the landslides only indirectly, through other geomorphologic parameters (fragmentation, declivity, relief energy etc.) The highest frequency of landslides it's considered to be rated between 200 -250 m altitude (37, 842%) that corresponds mostly to slopes, while the range 250 – 300 has a smaller share of only 26, 834 %, followed by 150 – 200 m altitude which has 21, 534 %. Insignificant frequencies are registered within 350 - 400 range (2, 421 %) or bellow 100 m altitude (2, 228 %).

Figure 3 Bulhac behind sliding moticulas on the right slope of Buda stream

Figure 4 Step sliding on right slope of Buda (Stemnic) stream around Chetresti area

Figure 5 *Cornice detachment of 'pit' sliding near town Răduieşti on right slope of Stemnic*

In relation with the slope, the landslides are distributed almost entirely between 5 - 25^o (99,865 %), 48,023 % are terrains with a slope of 10 – 15 ^{o}, and 33,488% are on terrains with a slope range between 5 – 10^o. (Fig. 6).

Interpreting the distribution of landslides according to the depth of fragmentation it can be seen that the maximum frequency of the processes is specific to the sectors characterized through values of vertical fragmentation of 75-100 m (49, 345 %) and 50 – 75 m (25, 895%).

Table no.1 Distribution of landslide on slope categorie

Class	Surface (ha)	Percentage (%)	Cumulate Frequencies (%)
≤ 1°	0,00	0,000	0,000
1 - 3°	1,64	0,128	0,128
3 - 5°	8,17	0,639	0,767
5 - 10°	428,18	33,488	34,255
10 - 15°	614,02	48,023	82,278
15 - 25°	224,87	17,587	99,865
> 25°	1,72	0,135	100,000
Total	1278,60	100,000	

Table no. 2 Distribution of landslide on the drainage depth class

CLASS	Surface (ha)	Percentage %	Cumulate Frequencies
	0,00	0,00	0,00
≤ 50 m	57,58	4,503	4,503
50-75 m	331,09	25,895	30,398
75-100 m	630,93	49,345	79,743
100-125 m	233,68	18,276	98,019
> 125 m	25,33	1,981	100,000
TOTAL	1278,60	0,000	100,000

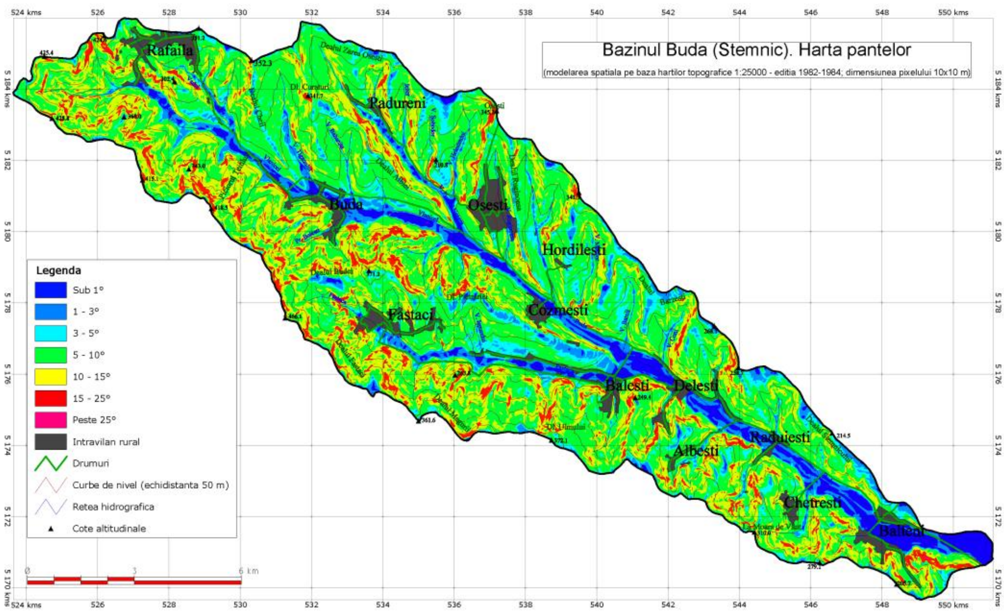

Figure 6 Buda catchment. Slopes map

The results of the analysis regarding the mass movement gravity processes refers to their distribution within the water catchment area based on the lithologic substrate, slope, and fragmentation depth ,but I have also took in consideration a presentation of the movement type based on their morphology and genesis. As shown in the studied water catchment area are more obvious, based on morphology, monticular slides, step slides and ‘pit’ slides. The analysis of geological surface deposits proves the presence of landslides with a higher frequency on kersonian deposits that are more common on the surface of the basin and that are constitutes out of clays, marl-clays, sandy clay, and that are vulnerable to displacement, when the other morphometric parameters are potentially accomplices. Hypsometric areas with slide bodies extended to lower altitudes are found on altitude steps between 200-300 m, and then their presence drops to altitudes lower than 150 m, but on the interfluves surfaces as well. The terrain inclination emphasizes the distribution of the sliding bodies with a higher sliding frequency between 5 and 25^o with a higher share in a range of 10-15^0

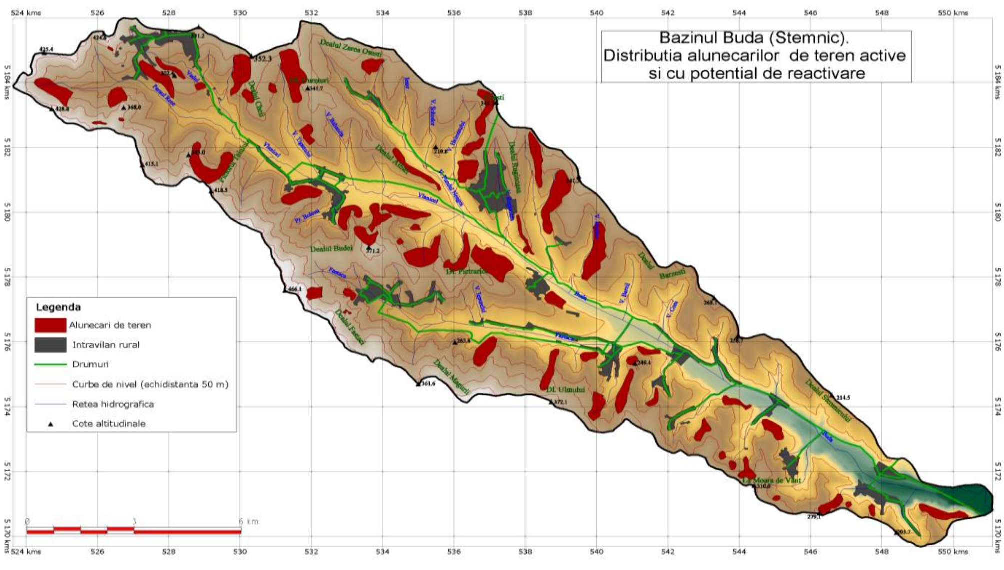

Figure 7 Distribution of landslides in Buda (Stemnic) catchment

Conclusions

The distribution of the landslides within water catchment area emphasizes the decisive role of geologic deposits, of the relief through slopes inclination, altitude and fragmentation energy. The most common bodies with landslides are encountered in the middle and superior sector if the basin, that have as well the larger surfaces, frequently on the slopes with inclination in a range between 15–25^{o}. On the inferior part of the basin the sliding bodies are fewer representatives, with small dimensions and it occupies mostly the slopes from the right side of the basin.

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