GEOMORPHOLOGICAL CONSIDERATIONS ON THE LANDSLIDES IN THE BAHLUIEŢ CATCHMENT

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Abstract: This paper focuses on the study of spatial distribution of the landslides and associated triggering factors within the Bahluieţ catchment. This area of 55,824 ha is subjected to land degradation, landslides being the most characteristic geomorphologic process, playing an essential role in the morphogenesis of the landforms and representing a major threat to agriculture land and human settlements. In order to analyze the landslides distribution, the field surveys, the topographic maps and the ortophotoplans of the year 2006 have been used. Landslides are stretching on 19,550 ha, representing 35% of the studied area. Presently, most landslides have a high degree of stability, due to the drier period of time since 1982, while the active landslides have a reduced incidence.

The highest frequency of landslides occurs on steeper slopes, mainly in the shape of cuesta fronts, usually northern and western facing.

Keywords**:** *Bahluieţ catchment, G.I.S, landslides, triggering factors.*

1. Introduction

The Bahluieţ catchment is located in the Moldavian Plateau and it overlaps three distinct relief sub-units: the eastern border of the Suceava Plateau in west, the Coasta Iasilor as the northern border of the Central Moldavian Plateau (*David M., 1941*) in south and the most important as extension, the Moldavian Plain (*Băcăuanu V., 1968*) or the Jijia Rolling Plain (*Ungureanu Al., 1993*) in the remaining area (Figure 1). This leads to a great diversity of physical-geographical conditions where the varied local landforms developed, and having multiple implications on the present-day geomorphological processes. The Bahluiet catchment covers 558.2 km^2 (55,823.5 ha) and from administrative point of view it is entirely situated in Iaşi County comprising 17 communities.

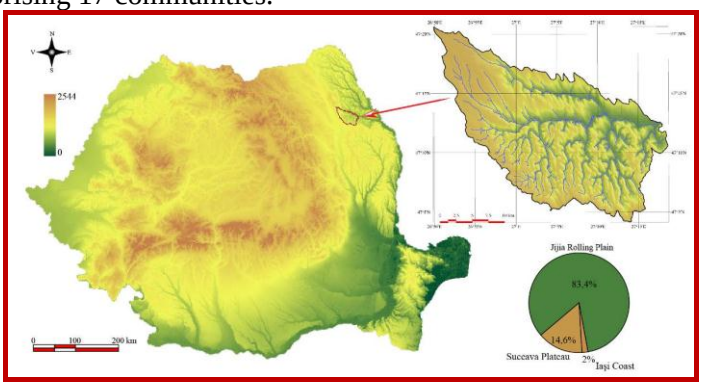

Figure 1. Geographical location of the Bahluieţ catchment.

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2. Material and methods

The study of landslides from the Bahluieţ catchment was carried out to establish a correlation between the triggering factors and the spatial distribution of these geomorphologic processes. Data acquired during field surveys have been completed with information gathered from digitized topographical maps at scale 1:5,000, 1979's edition, and subsequently correlated with information resulting from the interpretation of ortophotoplans. In order to create an inventory of landslides within the catchment, the TNT Mips v.6.9 program has been used. On that basis the Digital Elevation Model (DEM) at scale 1:5,000 and the associated thematic maps (hypsometric map, slope map, shape map and shading map) have resulted.

The inventory of landslides was a first step for our analysis, through which was intended to highlight the relationships between the distribution of these processes and the morphometric and morphographical indicators: the altitude, the geodeclivity and the slopes orientation.

3. Results and discussions

From geomorphological point of view, the sculptural landform is prevailing, developed in general monocline structure (*Băcăuanu V. et al., 1980*). The main morphographic feature of the Bahluieţ catchment subscribes to the general pattern of the Jijia Rolling Plain, described by elongated rolling hills, (*Băcăuanu V., 1968, Ungureanu Al., 1993*). In the local landscape appears a specific contrast between the long, gentle cuesta back slopes, and the cuesta fronts (escarpments), short, affected by present day geomorphic processes.

In the Bahluieţ catchment, landslides represent the most characteristic geomorphological process, having the highest probability to produce damages and contributing to reduce the crop yields and to diminish the soil quality.

The triggering and development of landslides are controlled by the local factors, namely: geology, relief, climate, hydrography, vegetation and the land use. *Pujină D. (1997, 2008)* conducted a long-term assessment of the geo-morpho-dynamic activities on slopes, showing that 4.2 years are required for the triggering and the developing of a landslide in the Jijia Rolling Plain.

The geological background of the catchment, represented by the Bessarabian layers laid in marine brackish facies, is predominantly marl-clayey with sandy intercalations *(Ionesi L., 1994, Brânzilă M., 1999)*. These sedimentary formations are arranged in a general monocline structure, with a gentle dipping of 7-8 m/km towards SSE. The prevailing clayey lithology with sandy seams favors the occurrence of landslides on large scale.

The Cryptomactra layers are represented by blue-gray, compact or poorly stratified clayey-marls (*Ştefan P., 1989*). Typical for the outcrop of the Cryptomactra layers are the whitish saline efflorescenses, rich in sodium sulphates, appearing more visible during dry periods (*Brânzilă M., 1999*).

The climatic factor plays also an important role in triggering and development of landslides. From climatic point of view, the study area belongs to temperate continental climate, with average annual temperature of 8.3-9.6˚C. The average amount of precipitation in the Bahluieţ catchment is 600-700 mm, with higher values on the Coasta Iasilor and Suceava Plateau and smaller in the Jijia Rolling Plain. The seasonal distribution is 75.9% in warm season and 24.1% in cold season, and the monthly peak is reached in June. Up to 40% of all rainfalls are recorded during the summer months. This distribution has a significant effect on the development of mass movements.

A further factor contributing to the occurrence of landslides is the inappropriate anthropic practices such as the improper land use after deforestation, overgrazing for extended periods of time, etc. It was noticed the extension of the agricultural system consisting into small up and down hill parcels (plots) as resulted from the application of the Land Property Act no.18/1991. It is noteworthy that forests cover only 12% within the study area.

Under these conditions it was estimated that landslides covers 19.550 ha, representing 35% of the Bahluiet catchment area (Figure 2). They mainly affect steep slopes of the cuesta fronts, western and northern looking and some degraded cuesta backslopes.

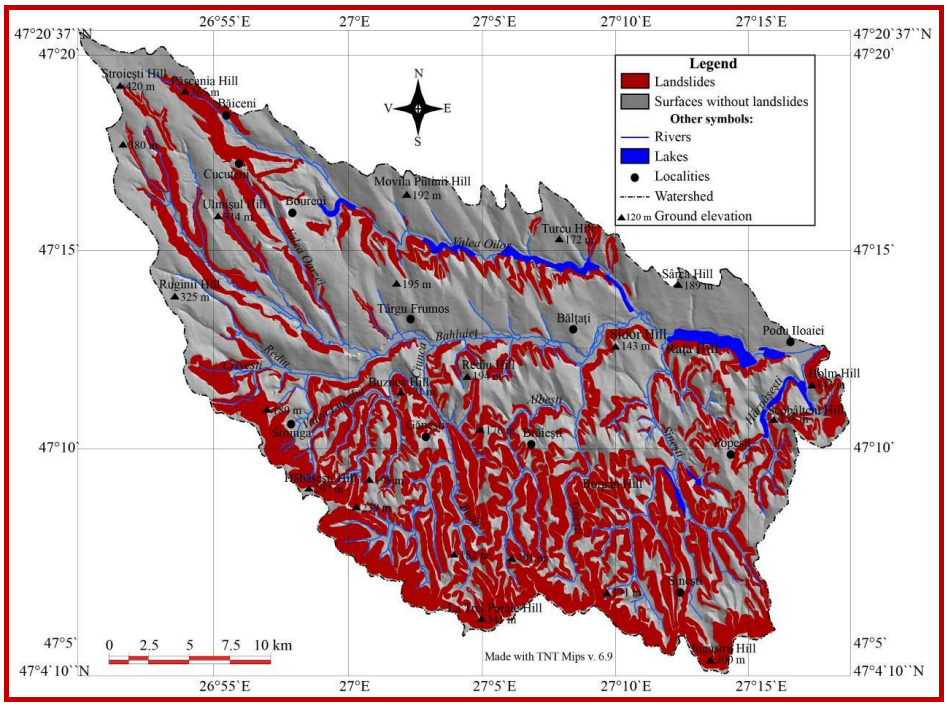

Figure 2. Distribution of the landslides in the Bahluieț catchment

Figure no. 2 illustrates the distribution of landslides within the study area and highlights their "preferentially" development on the slopes that form a chain of cuesta escarpments. Those northern looking cuesta fronts accompany the subsequent sectors of the Oilor and Bahluieț Valleys in the northern area and the Coasta Iasilor on the southern border. However, the most significant landslide development occurs in the southern area of the Jijia Rolling Plain, where the right tributaries of the Bahluiet River have sculptured general obsequent valleys including short subsequent reaches. These younger obsequent valleys such as Sineşti Valley, Albeşti Valley, Goeşti Valley, Ciunca Valley are emphasizing the second order structural asymmetry, typified by western looking cuesta fronts and eastern facing cuesta backslopes *(Ioniță I., 2000a)*. The high rate of the relief fragmentation, the fast deepening of the hydrographic network and the undermining of slopes in that area resulted in significant extension of the landslides on the cuesta backslopes, too *(Ioniță I., 2000b)*.

The oldest and deep seated landslides occur in the famous Coasta Iasilor, which is characterized by high relief energy. *Martiniuc C. and Băcăuanu V. (1982)* regard them as being Upper Pleistocene in age "*probably in Wurm*" and developing "*during at least three successive cycles*." These landslides are the most extended both in surface and in depth. The thickness of deluvium was estimated by the same authors as being on average of 20-30 meters, sometimes reaching up to 50 m. The average area of the landslide perimeters is 25.6 ha, the variation being between 0.9 ha and 111.6 ha.

The landslides are in different evolution stages. Those active are small sized, appear punctually and most of the time they are actually representing reactivations of the old sliding deluvium.

Morphologically, waves-like shape landslides are prevailing, occurring on the cuesta fronts of which we mention the right slope of Oii Valley in the middle course (Figure 3), the left slope of Sineşti Valley upstream of Osoi or the left slope of Albeşti Valley upstream of Brăieşti. This type of landslides is usually associated with steps-like and mound landslides. The sliding deluvium is made up by a mixture of loams, clays, marls and sands having a small thickness of 1-5 m or a moderate thickness of 5-10 m.

The steps-like landslides are generally common within the study area, occurring on pronounced uneven slopes, made up by alternations of clays, sands, with rich aquifers layers *(Băcăuanu V., 1968)*. The most obvious example in this regard is the landslide developed on the left side of Sineşti Valley, downstream of Zmeu village (Figure 4).

Figure 3. Waves-like shape landslides on the right side of Oii Valley, downstream of Filiaşi (22 June 2011)

Figure 4. Steps-like shape landslides on the left side of Sineşti Valley, downstream of Zmeu (05 April 2012)

In the Sineşti catchment, landslides of different amplitudes and development stages occur on large areas, affecting almost half of the entire basin (47.4%). The complex landslides usually develop on the slopes characterized by high relief energy, with a varied geological structure (clays, sands, marls), covered by a loessoid blanket (Figures 5 and 6).

Figure 5. Complex landslide on the left side of Sineşti Valley, upstream of Osoi (06 October 2012)

Figure 6. Complex landslide on the left side of Oii Valley, downstream of Podişu (22 June 2011)

As a triggering mechanism, the regressive landslides prevail that develop from the foot of the slope and evolves towards the ridge. An example in this way is the landslide developed on the right slope of Bahluieţ valley, south of the Podu-Iloaiei.

The geomorphologic factor acts and contributes to the preparation, triggering and the evolution of dynamic landslide process by pre-existing landscape features (declivity, relief energy).

From a hypsometric point of view, the average altitude of the relief reaches 165 m, with maximum relief amplitude of 376 m, between the lowest altitude of 56 m, at the junction with Bahlui River and the peak of 432 m, in the Bahluieţ headwater, in the Stroeşti Hill. As to the distribution of landslides according to the elevation, it is noticeable that these processes develop with maximum intensity between 100-250 m, an area almost entire situated within the Jijia Rolling Plain (Figure 7).

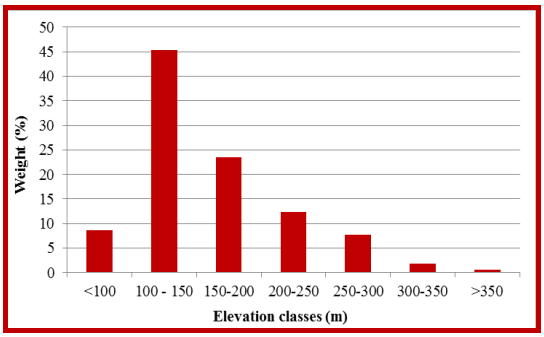

Figure 7. Distribution of the landslides by elevation classes

An important feature in landslide triggering is the geodeclivity of the landforms. The most important forms created by the landslides occur where the declivity is high and where there are considerable springs at the base of large mass of permeable material.

The average value of slopes is 7.2% and most land slope values (46.5% of total) vary between 5-18%. These values indicate a specific type of fragmentation of the land which determines the presence of large, quasi-horizontal surfaces, flanked by steeper slopes. The slope values with smaller values than 5% are characteristic for the floodplain, structural-lithological plateaus and for the majority of the hilltops. The areas where the slope values exceed 27% (10.3% of the total) occur in the north-western side of the catchment, in spring's area and on the cuesta fronts, corresponding to the scarp of some landslides or to some gullies banks.

If the landslide surface is associated with the relief declivity, it can be noticed that two thirds of the landslides occur on slopes between 10-27% (Figure 8). The slopes with values between 18-27% are the most affected by landslides (39%). The decrease in frequency of landslides on steeper slopes reflects a decreasing proportion of these hill-slopes within the catchment, since the slope values of 27-36% occupy only 7% of the entire basin.

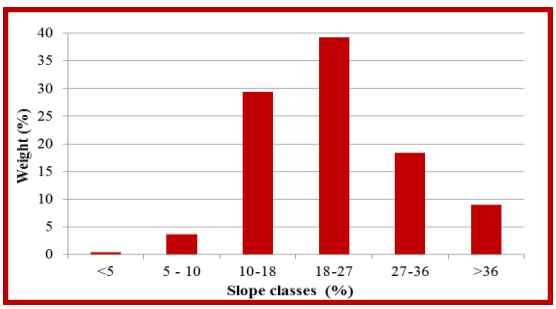

Figure 8. Distribution of the landslides by slope classes

The relationship of the slopes affected by landslides with their exposure points out that the highest values characterize the north-eastern and western looking slopes (Figure 9). The lowest values of landslide distribution by orientation classes occur on south and south-east facing slopes, which are cuesta backslopes with gentle slope.

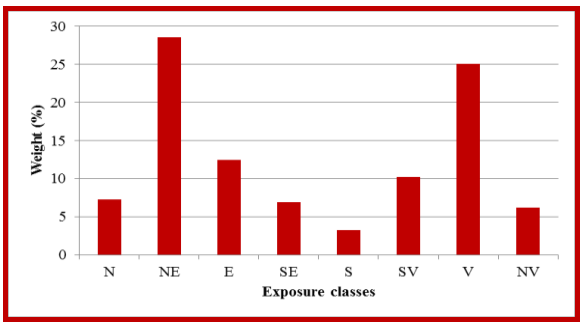

Figure 9. Distribution of the landslides by exposure classes

4. Conclusions

Landslides cover 35% of the studied area, that through their development, dynamics and created landforms are the most representative degradation processes.

The considerable development and distribution of landslides are resulting from predominantly Bessarabian clayey-sandy facies within a prevailing rolling hilly area. Most landslides are old and stabilized, while the active ones have a reduced incidence. The landslides occur specially in the southern part of Jijia Rolling Plain where the right tributaries of the Bahluiet sculptured general obsequent valleys. Then, the Coasta Iasilor follows, where the oldest and deep seated landslides are located. The highest frequency of landslides occurs on the cuesta fronts with northern and western orientation, but also on highly degraded cuesta backslopes. The average surface of a landslide is 15.6 ha, the variation being between 0.9 - 111.6 ha.

The most favorable conditions for the landslides development occur on slopes between 150-200 m altitude, the most subjected to these geomorphological processes being north-eastern and western looking slopes with values between 18-27%.

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