



LAND DEGRADATION WITHIN THE BAHLUIEȚ CATCHMENT

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Key words: land degradation, soil erosion, gully, landslides, sedimentation

Abstract. The Bahluiet catchment, located in the Moldavian Plateau, at the contact between the Jijia Rolling Plain, the Suceava Plateau and the Central Moldavian Plateau, has 54,866 hectares in size. The sculptural landforms are prevailing, described by elongated rolling hills, and are underlain by the Bessarabian layers laid in marine brackish facies. In turn, the typical plateau relief (Coasta Iasilor and the eastern border of the Suceava Plateau) is developed in coastal facies also Bessarabian in age.

This paper focuses on the spatial distribution and intensity of land degradation processes and associated controlling factors within the Bahluiet catchment. The most characteristic geomorphological processes, playing an essential role in the morphogenesis of the landforms are soil erosion and landslides, while gully erosion and sedimentation have a reduced intensity.

Soil erosion is ubiquitous, being the process with the highest extension. Therefore, the soils on the arable land, affected by moderate-excessive erosion, hold a weight of 38%. The slopes subjected to landslides are stretching on 19,040 ha, representing 35% of the studied area. Nowadays, most landslides show high degree of stability, due to the drier period of time since 1982. The gully erosion has a reduced incidence resulting from the prevailing Bessarabian clayey-sandy facies. The average rate of sedimentation in reservoirs, after the year 1986, is around 2 cm yr⁻¹.

Land degradation within the Bahluiet catchment occurs on steeper slopes, mainly in the shape of cuesta fronts, usually northern and western facing, but also on some degraded cuesta back slopes.

1. Introduction

The Bahluiet catchment is located in the Moldavian Plateau, at the contact between three distinct relief sub-units: the eastern border of the Suceava Plateau in

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west, the Coasta Iasilor as the northern border of the Central Moldavian Plateau (David M., 1941) at south and the Moldavian Plain (Băcăuanu V., 1968) or the Jijia Rolling Plain (Ungureanu Al., 1993) in the remaining area as the most extended subunit (Figure 1). This triple intersection leads to a great diversity of physical and geographical conditions where the varied local landforms developed, and having multiple implications on the present-day geomorphological processes. The Bahluiet catchment covers 54,866 ha and from administrative point of view it is entirely located in the Iași County comprising 20 communities.

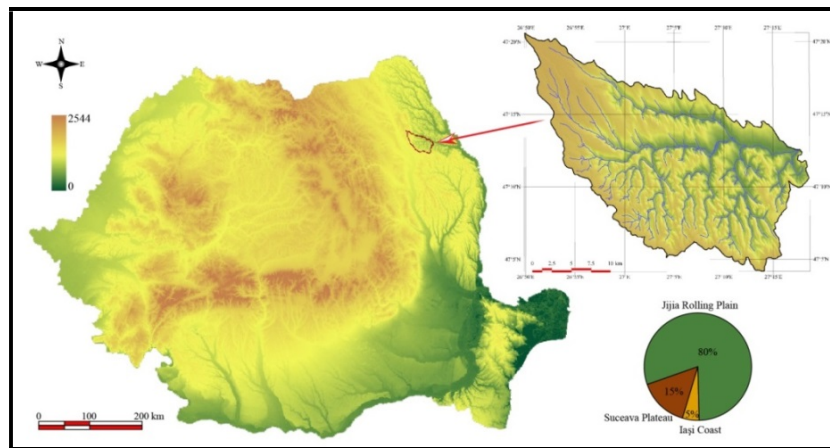


Fig. 1. Geographical location of the Bahluiet catchment

The natural and anthropogenic controlling factors (geological, geomorphologic, climatic, hydrologic, pedological, biotic and anthropogenic factors) have shaped the current landscape and influenced the present day geomorphological processes. The most characteristic degradation processes, playing an essential role in the morphogenesis of the landforms are soil erosion, landslides, while gully erosion and sedimentation show low intensity.

2. Material and methods

In order to assess the spatial distribution, the intensity of land degradation processes and associated controlling factors within the Bahluiet catchment, both the classical and modern methods have been used.

Data acquired during field surveys have been completed with information gathered using Geographical Information System (G.I.S.) techniques, the interpretation of orthophotoplans from 2009 and with the soil surveys carried out by O.S.P.A Iași.

The spatial modeling was performed using TNT Mips software V.6.9., and as a result we have primarily succeeded in making of the Digital Elevation Model (DEM) and subsequently a series of useful thematic maps, such as hypsometric map, slope map and exposition map.

By using the G.I.S. tools the land degradation intensity was evaluated and several spatial distribution maps for land degradation were accomplished. Therefore, the map of soil erosion was drawn using data on the intensity of soil erosion, from soil surveys carried out by O.S.P.A. Iași, at scale 1:10,000. The maps of gullies and landslides distribution resulted from the combination of data collected during field surveying with the information taken from orthophotoplans.

The assessment of the average sedimentation rate within reservoirs is based on the results obtained by *Ioniță I. et al. (2000)* by using the ^{137}Cs technique.

3. Results and discussions

The general landforms characteristics are the result of the steady interaction between internal and external factors. However, the current landscape physiognomy of the Bahluiet catchment was mainly due to the sculptural activity of the external factors that have shaped in time the original surface, while the internal factors played a subsequent role. The main landforms are represented by the hilltops and deluvial slopes. Most of the slopes are actually either cuesta back slopes or cuesta fronts and their facing is strongly connected to the double structural asymmetry in the Moldavian Plateau as described by *Ioniță I. (1998, 2000)*.

The geological background of the catchment, represented by the Bessarabian sedimentary layers laid in marine brackish facies, is predominantly clayey-marl with sandy seems, while the typical plateau relief (Coasta Iasilor and the eastern border of the Suceava Plateau) is developed in coastal facies (*Ștefan P., 1989, Ionesi L., 1994, Brânzilă M., 1999*). These sedimentary formations show a gentle dipping of 7-8 m/km to SSE, typical for a general monocline structure (homocline).

The climatic features, either through direct impact or interaction with other factors, are highly interrelated with land degradation. Climatically, the study area belongs to the temperate continental climate, with average annual temperature of 8.3-9.6°C. The average amount of precipitation in the Bahluiet catchment varies between 530-700 mm, with higher values in the Coasta Iasilor and Suceava Plateau and smaller ones in the Jijia Rolling Plain.

The natural vegetation comprises two zones, namely: the first one specific to the Eastern European silvo-steppe zone and secondly the forest area associated to the Central Europe. Accordingly, two main soil classes have been identified. Firstly, the Chernisols class is weighing 60% of the total agricultural land, including mainly Chernozem and Phaeozem soil types and extending in the Jijia

Rolling Plain. Secondly, the Luvisols class, with Preluvosol (Entic Luvisol) and Luvisol types, which are prevailing in the higher area, the Suceava Plateau and Central Moldavian Plateau.

The land degradation processes are strongly influenced by the inappropriate human practices, such as the improper land use after deforestation, overgrazing for extended periods of time etc. Recently, it was noticed the extension of the traditional agricultural system, consisting into small up and down hill plots, resulted from the application of the Land Act no.18/1991. Today, the forest cover is weighing only 12% within the study area. Currently, there are remaining only 392 ha, representing 1.6% of the arable land, under previous soil conservation practices.

3.1. Soil erosion

Among the degradation processes, the largest spatial extension is associated with soil erosion covering with different intensity the slopes with gradients over 5%.

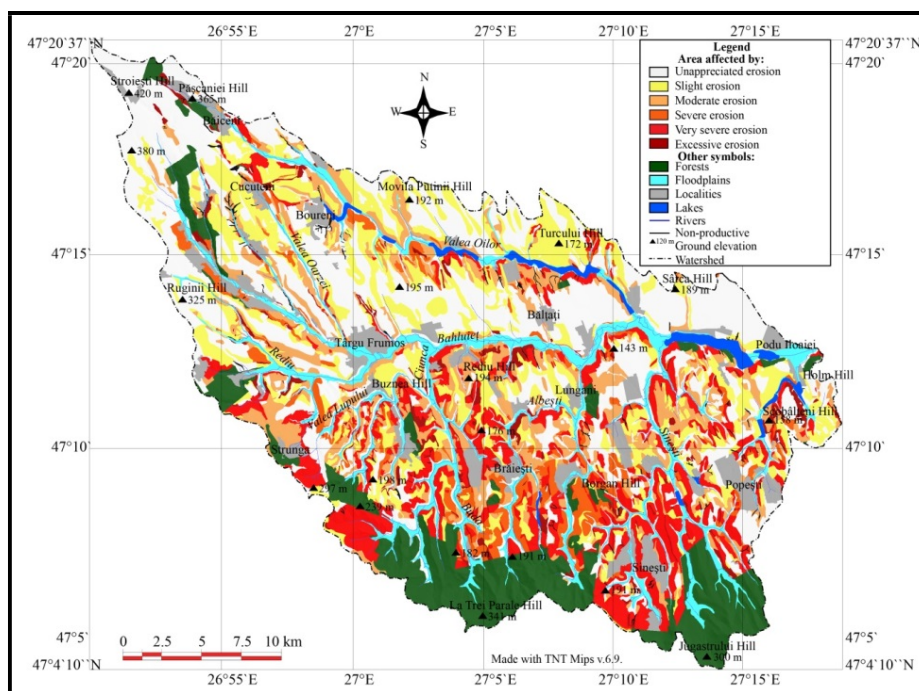


Fig. 2. Map of soil erosion intensity on the agricultural land within the Bahluiet catchment (processing after soil surveys of O.S.P.A. Iași)

The Figure 2 illustrates the spatial distribution and the intensity of soil erosion on agricultural land within the study area. The mapped area is 40,057 ha, weighing 73% of the entire catchment. The remaining of 27% represent non-agricultural areas under forests, localities, lakes, without direct observations about the soil erosion.

There is a noticeable difference regarding the spatial distribution and the intensity of the soil erosion within the Bahluiet catchment. Therefore, the largest weight is held by land under unappreciated erosion (38%). However, the moderate-excessive eroded soils on the arable land cover 15,244 ha representing 38% of the total (Figure 3).

The intensity of this geomorphological process is influenced by the characteristics of the soil, through the degree of mechanical resistance to erosion.

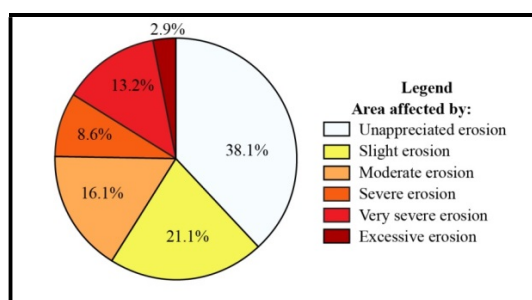


Fig. 3. Soil erosion intensity on agricultural land within the Bahluiet catchment

According to *Moțoc M. (1975)*, the slope of the landforms is the most important factor in triggering soil erosion, being responsible for accelerating the water run-off and increasing the power of detachment and transport of solid particles.

As to the distribution of soil erosion by slope classes, it is obviously that this process develops with maximum intensity on slopes between 10-18% (Figure 4). On gentler slopes, under 10%, the unappreciated or slight erosion prevails, while the areas where the slope values exceed 18% are characterized by severe and excessive erosion.

Soil erosion occurs with different intensity by landforms. Thus, the unappreciated erosion is specific to structural-lithological plateaus, hilltops and slight degraded cuesta back slopes. Moderate erosion represents 16% of the mapped area, occurring with similar weight on landforms (Figure 5). In turn, the highest intensity of soil erosion characterizes both the western and northern looking cuesta fronts, including some highly degraded cuesta back slopes.

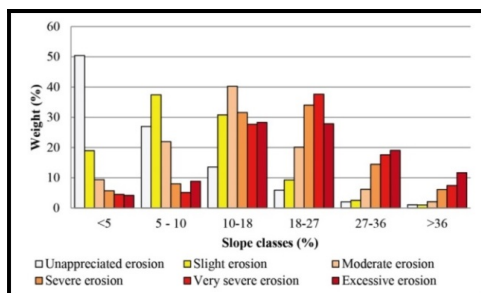


Fig. 4. Distribution of soil erosion intensity on agricultural land by slope classes

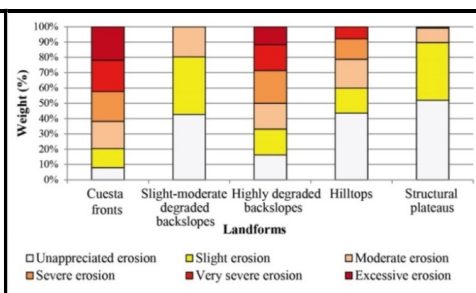


Fig. 5. Distribution of soil erosion intensity on agricultural land by landforms

Soil erosion extends mostly on the highly degraded cuesta back slopes, eastern facing, of the obsequent valleys from the southern compartment of the catchment, of which we mention the left slope of Albești, Goești, Ciunca, Sinești Valleys (Figure 6).



Fig. 6. Soil erosion on highly degraded cuesta back slope, on the left side of Albești Valley, upstream of Brăești (30.03.2014)

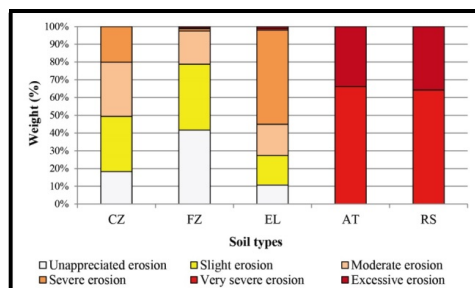


Fig. 7. Distribution of soil erosion intensity on agricultural land by soil types

Regarding the relationship between the intensity of soil erosion and types of soil, represented in the figure 7, it is noticeable that the land with unappreciated erosion belong to Chernisols class. The increased weight of eroded Anthrosols and Regosols (22%) emphasizes the development and the intensity of the soil erosion.

3.2. Gully erosion

The gully erosion shows low incidence due to the predominantly Bessarabian clayey facies and loamy-clayey soils which are more resistant at erosion. The area occupied by gullies is 610 ha, representing only 1% of the catchment, but often, the incision by gullying is the main factor triggering the regressive landslides (Figure 8). Under these circumstances, the initial gully configuration changes very quickly.

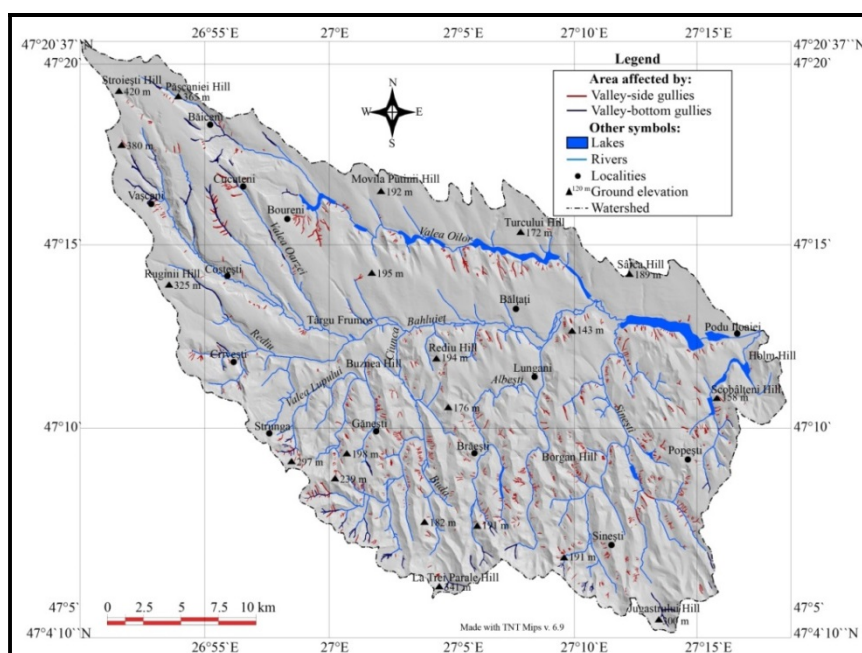


Fig. 8. Distribution of gullies within the Bahluiet catchment

Valley-side gullies are the most widespread and occupy two-thirds of the gullied area, 415 ha (68%), compared to the valley-bottom ones with only 195 ha (32%). The discontinuous gullies, small in size, are more frequent within the study area, occurring especially on the slopes. Valley-side gullies are associated with small catchments and they form in A or B horizons, and rarely in the C horizon of the soils. The main factors of gully initiation and development are the hydrological factor (the concentrated runoff) and the lithological factor (Ioniță I. 1998, 2000).

Gullies are stretching mostly on steeper slopes where the soil is poorly protected by vegetation.

In the western compartment of the study area, gullies have great development, of which stands out the Băiceni-Cucuteni gully on the morphological escarpment, Dealul-Mare Hârlău, within the Valea Oilor catchment (Figure 9).



Fig. 9. Băiceni-Cucuteni gully on the morphological escarpment, Dealul-Mare Hârlău, north of Cucuteni village (09.03.2014)

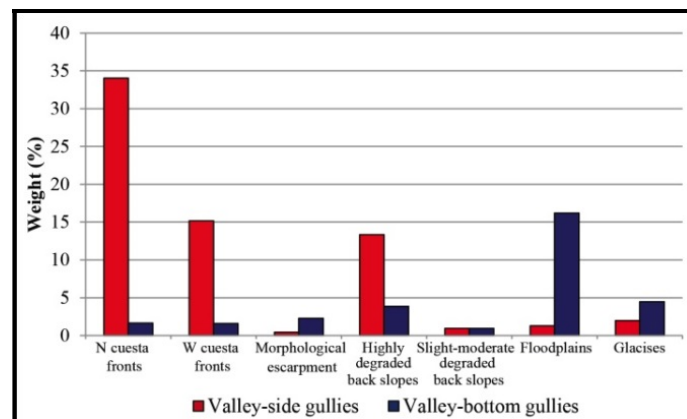


Fig. 10. Distribution of gullies by landforms

The figure 10 clearly suggests the prevailing distribution of the valley-side gullies on cuesta front slopes, both northern and western looking (70.5%), followed by the gullies developed on the degraded cuesta back slopes (22.5%). Valley-bottom gullies occur especially on floodplains and glacises (66.7% of the total).

Figure 11 shows the distribution of gullies by land use. Gully erosion is, generally, most highly developed on pastures, forests, followed by arable land, vineyards and orchards.

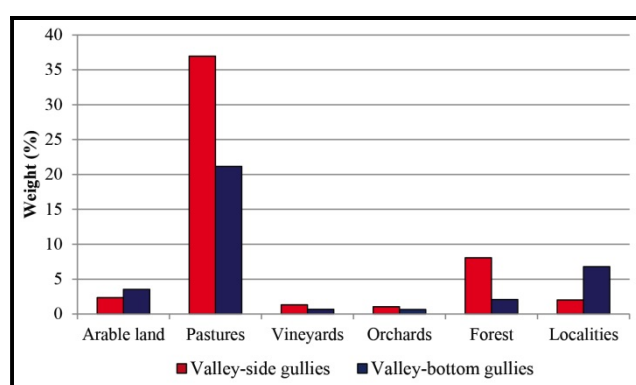


Fig. 11. Distribution of gullies by land use classes

3.3. Landslides

Landslides are the most significant geomorphologic process and representing a major threat to agriculture land and human settlements. The slopes subjected to landslides are extending on 19,040 ha, representing 35% of the studied area. At present, most landslides depict high degree of stability due to the drier period of time recorded since 1982, while the active landslides have a reduced weight of about 3.5% of total. The prevailing clayey lithology with sandy seams favors the occurrence of landslides on large scale. The highest frequency of landslides occurs on steeper slopes, mainly in the shape of cuesta fronts, usually northern and western facing. However, the most imposing landslide development occurs in the southern area of the Jijia Rolling Plain, namely in the southern compartment of the Bahluiet catchment.

The figure 12 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 cuesta fronts accompany the subsequent sectors of the Oilor and Bahluiet Valleys in the northern area and the western cuesta fronts in the southern compartment, plus Coasta Iasilor.

Grozavu A. et al. (2012) estimated the landslides susceptibility in the Brăiești-Sinești area, showing that half of the region is characterized by very low and low

susceptibility, while the land with high and very high susceptibility represent about 29% of the total.

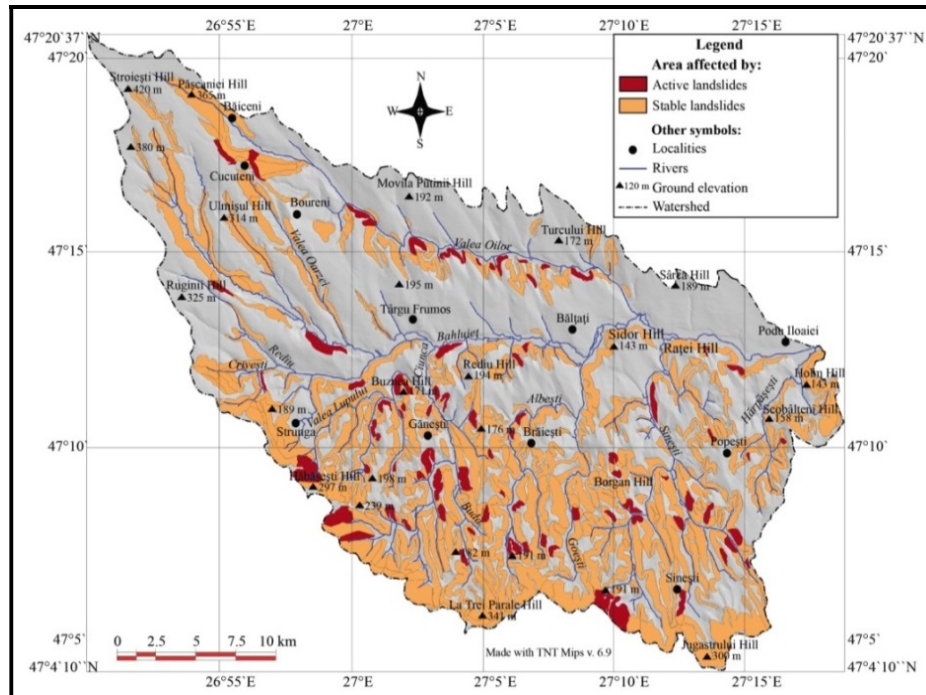


Fig. 12. Distribution of landslides within the Bahluiet catchment

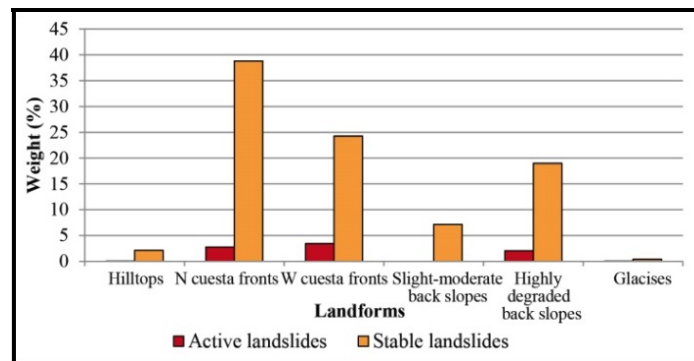


Fig. 13. Distribution of landslides by landforms

Landslides, both active and stable, mainly affect strongly steep slopes of the cuesta fronts, western and northern looking and some degraded cuesta back slopes.

The hilltops, slight-moderate degraded cuesta back slopes and glacises are insignificantly affected by landslides (Figure 13).

The high rate of the relief fragmentation/incision, 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 back slopes, too (Popa Ionela, 2014).

Morphologically, the waves-like shape landslides are prevailing, but also steps-like landslides are generally common within the study area. A particular type of landslides, locally called „hârtoape”, resembles an amphitheater, being located on the slopes or at the origin of torrential valleys. Landslide amphitheatres are characteristic to cuesta fronts, such as the one south to Osoi and Stornești villages (Figure 14).



Fig. 14. Typical hârtoape (landslide amphitheater) in the upper Sinești catchment, Piscul Rogosului Hill of 300 m (photo I. Ioniță, 4.04.2014)

According to the graph from Figure 15, pastures are the most affected by landslides, followed by forest. Thus, two-thirds of the landslides affect the pastures and forest and only 12% of landslides occur on the arable land.

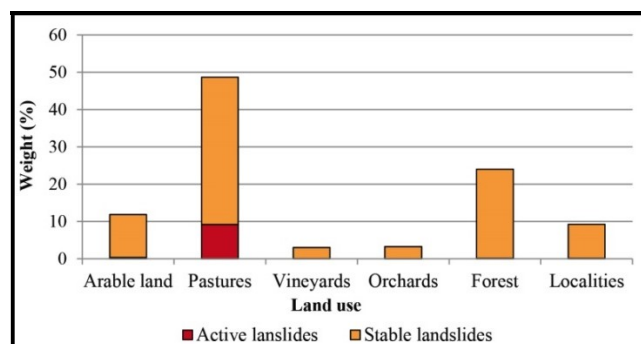


Fig. 15. Distribution of landslides by land use

3.4. Sedimentation

In addition to soil erosion, gullying and landslides, sedimentation is another geomorphological process within the Bahluiet catchment.

The results provided by *Ioniță I. et al. (1998, 2000)*, by using of ^{137}Cs measurements, made possible to estimate accurately quantitative rates of sedimentation in the Moldavian Plateau reservoirs. For example, the Cs-137 depth profile in the Doroșcani reservoir, shows an average sedimentation rate of 1.5 cm yr^{-1} between 1963-2008 (Figure 16).

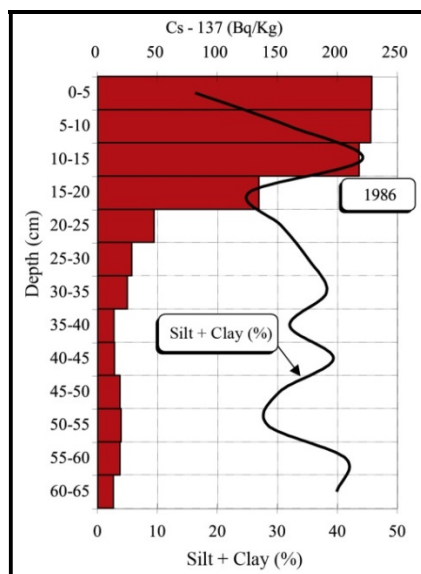


Fig. 16. Distribution of Caesium-137 in the Doroșcani reservoir in Popești-Scobâlțeni catchment (Ioniță I. et al., 1998)

Data from table 1 are showing an average low rate of sedimentation in reservoirs of 2 cm yr^{-1} , after the Chernobyl nuclear accident dated on 26 April 1986. The sedimentation rate for the Moldavian Plain, of 2.4 cm yr^{-1} is by far the most reduced value in the Moldavian Plateau.

Tab. 1. Mean annual sedimentation rates since April 1986 for representative reservoirs within Bahluiet catchment (Ioniță I. et al., 2000)

No. crt.	Reservoir	Mean rate of sedimentation (cm yr^{-1})
1	Doroșcani - Popești	1.5
2	Doroșcani	2.3
3	Podu-Iloaiei	3.5
	Average	2.4

These low values are due to the predominantly clayey substratum, to the prevailing of soils with clayey loam texture, fairly resistant to erosion.

Conclusion

Land degradation by erosion and landslides is a major environmental threat within the Bahluiet catchment. Its distribution and development depends particularly on the landforms and land use. The highest frequency of land degradation occurs on the cuesta fronts with northern and western orientation, but also on highly degraded cuesta back slopes. Thus, the most eroded soils and the slopes subjected to landslides are located in the southern area of the catchment.

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