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CHARACTERISTICS OF THE LAND DEGRADATION IN THE STAVNIC RIVER BASIN

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Key words: soil erosion, gullying, landslides, sedimentation

Abstract. Located in the Central Moldavian Plateau, the Stavnic catchment is associated to a left tributary of the upper Barlad River, and extends on 21,341 ha of which 39% is under forest.

The typical hilly landforms, the alternation of permeable and impermeable rocks (clays, sands, loess-like deposits), the unrolling of wetted and dry periods, the sequence of freeze and thaw cycles, and the influence of the anthropogenic factor triggered the acceleration of land degradation processes. The present day geomorphic processes such as soil erosion, gullying, mass movements and silting of reservoirs represent a major threat to the local environment.

Soil erosion on the agricultural land covers mainly the land with slopes of over 5%, and it highlights through different stages of intensity. By data processing, gained from the soil surveys undertaken by O.J.S.P.A. Iasi and Vaslui, it is obviously that moderate-excessive soil erosion extends on 52% of the surveyed area.

The gully erosion apparently plays secondary role in the Stavnic catchment. However, there has been identified a total number of 330 gullies, most of them being included into discontinuous gullies class, often located on the hillslopes.

Landslides are the most representative geomorphologic processes and they extend on 12,006 ha, which represents 56% of the Stavnic catchment. One mention must be made, that in the context of climate aridisation occurred during the last three decades, the landslides are almost all stabilized. The majority of the few active landslides have frequently formed through the reactivation of the old landslide diluvia.

By using the Cesium-137 technique in dating the recent sediments from the Cazanesti accumulation, within the lower Stavnic catchment, the mean siltation rate of 4.5 cm yr^{-1} after the Chernobyl nuclear accident was estimated.

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Introduction

The term of „degradation" is opposite to the „aggradation" one, and it represents *„the processes that determine the depreciation of soil fertility and/or the quality of the land, due to soil erosion, landslides, salinization or marsh, compaction etc."* (Donisa et al., 2009). The Stavnic catchment is located in the eastern part of Romania, within the Central Moldavian Plateau, where occupies 21,340.8 ha representing 6% of the total plateau area.

The present day local topography is the result of a long-term development under the action of the endogenous factors (geological) and the exogenous ones.

Geologically, the sedimentary formations outcropping in the Stavnic catchment belong to the Middle Sarmatian (Bessarabian) and Upper Sarmatian (Chersonian). In addition, the recent deposits of Quaternary age have to be mentioned. The Bessarabian formations are prevailing, primarily in the marine-brackish facies (clays with sand seams) and secondly in the neritic-coastal facies which is highlighted by structural plateaus developed on the sandstone-limestone cap-rock. The clayey-sandy Chersonian layers occur discontinuously, especially on higher hilltops, in the form of erosion remnants (Jeanrenaud P., 1961, 1971, 1995).

The relief from the Stavnic catchment is typical hilly one, peculiar to the Central Moldavian Plateau, where the structural-lithological plateaus, the hilltops and cuesta fronts with general northern or western orientation are equally imposed.

The sculptural (fluvio-denudational) topography in general monocline structure (homocline) is the dominant type of relief since is extending on 72% of the Stavnic catchment. The valley-sides occupy most of the area and frequently they are either cuesta fronts or cuesta back slopes.

The temperate-continental climate with shades of excessiveness is characterized by the mean annual temperature of 7°C on the structural-lithological plateaus and on the summits with higher altitude, and of 10°C at the confluence of the Stavnic with Barlad River. The amount of average annual precipitation over the period 1961 – 2006 was 531 mm yr^{-1} at Vaslui, 577 mm yr^{-1} at Iasi and 780 mm yr^{-1} at Barnova, according to C.M.R.M. Iasi.

The largest areas of agricultural land have developed on Cernisols (4,487 ha), Luvisols (2,716 ha) and Aluvisols (2,232 ha). Also, the significant surfaces occupied by Anthrosols (918 ha) and Regosols (244 ha) suggest the particular intensity of soil erosion.

1. Material and methods

The study of land degradation processes in the Stavnic catchment was based on the field observations, geomorphological survey and the interpretation of the color aerial photos delivered in 2009. By using the TNT Mips v6.9 software the digital elevation model (DEM) was accomplished. It consisted on the vectorization of the topographical maps at 1:5,000 scale. By means of DEM a series of thematic raster layers and useful thematic maps have resulted, namely: hypsometrical map, slope map, shape map and shading map.

The geological substratum, the geomorphological, climatic and hydrological characteristics, as well as the anthropic intervention have triggered land degradation processes. The map of the intensity of soil erosion on agricultural land in the Stavnic catchment was drawn by digital processing of data from the soil surveys undertaken by O.J.S.P.A. Iasi and Vaslui at scale 1:10,000.

As a result of the field trips and of the validation of the cartographic materials, the areas subjected to gullying and landslides were identified. Another geomorphic process in the studied area is the sedimentation along the floodplains, in particular the reservoir silting.

2. Results and discussions

2.1. Soil erosion. Among land degradation processes, the largest spatial extension is associated with soil erosion which covers 8,655 ha, weighing 41% of the surveyed area. The remaining of 12,685 ha, weighing 59% represent non-agricultural land under forests (40% of the total remaining area), villages and lakes.

The extension of soil erosion on the agricultural land within the Stavnic catchment is a consequence of the interaction of the natural factors (typical hilly landscape, alternation of clays and sands, the high frequency of the heavy rainfalls, the prevailing of sloping land with erosion potential on 81% of the catchment area) with the human impact underlined by deforestation, expansion of the settlements, improper setting of the road network, as well as inappropriate farm practices (Bacauanu V. et al., 1980).

Fig. 1. Rill erosion on typical Preluvosol, on the right slope of the Stavnic Valley, south of Schitu Hadambu village (10 July 2010)

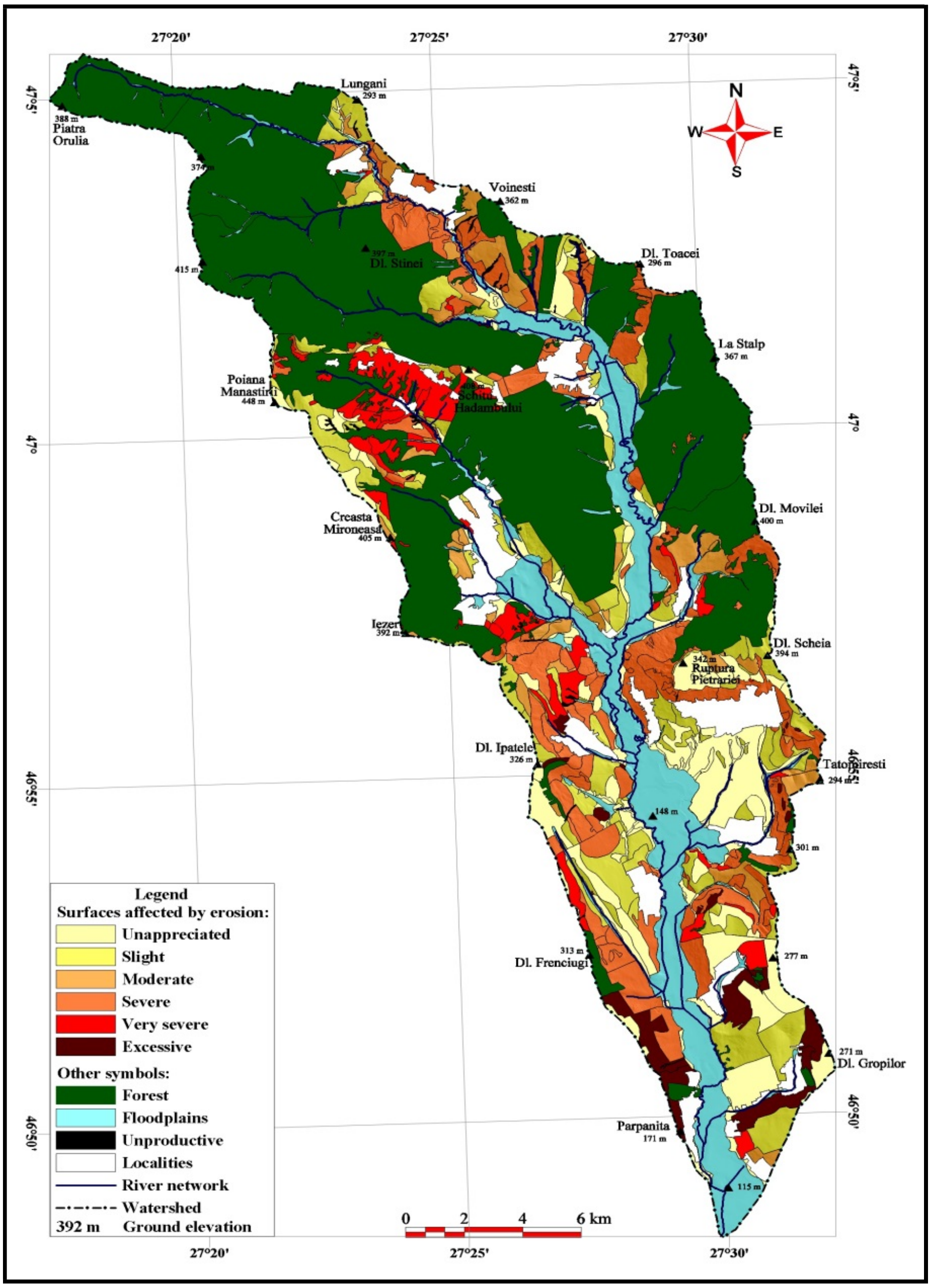

Fig. 2. Map of the soil erosion intensity on agricultural land within the Stavnic catchment (processing of O.J.S.P.A. Iasi and Vaslui soil surveys)

Rills are the most advanced form of soil erosion and they show small size, a randomized model of distribution and don't occur every year in the same place. The rills are significantly developing on wooden soils, especially on Preluvosols and Luvosols, that have a well-defined Bt horizon (figure 1).

Figure 2 gives an image about the spatial distribution and the intensity of soil erosion on agricultural land with erosion potential. This map has resulted from data processing of the soil surveys carried out by O.J.S.P.A. Iasi and Vaslui.
A quarter of the mapped area (2,130 ha) is under unappreciated erosion and the moderate-excessive erosion occurs on 52% of the surveyed surface.

Figure 3 indicates that 2,199 ha, located on the cuesta fronts are subjected to severe-excessive erosion. Also, on the highly degraded cuesta back slopes the very severe erosion occupies 319 ha, and the remaining, 111 ha are under the excessive one.

The slightly-moderate degraded cuesta back slopes (1,095 ha), structural-lithological plateaus (775 ha) and glacises (774 ha) are mostly affected by unappreciated erosion.

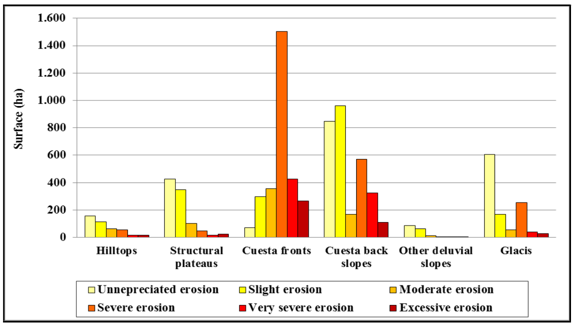

Fig. 3. Distribution of the soil erosion intensity classes on agricultural land by landforms (processing of O.J.S.P.A. Iasi and Vaslui soil surveys)

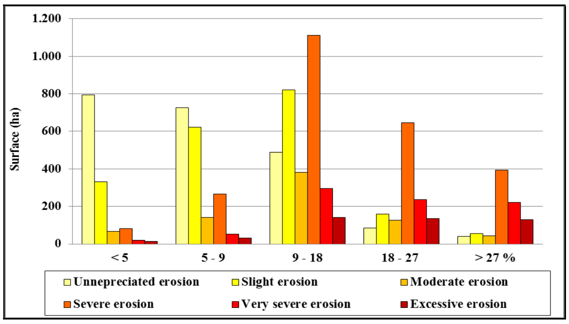

Fig. 4. Distribution of the soil erosion intensity classes on agricultural land by slopes classes (processing of the O.J.S.P.A. Iasi and Vaslui soil surveys)

The distribution of soil erosion by slope classes illustrates that half of the unappreciated erosion occurs mainly on very gentle land with slopes under 5%, namely 2,490 ha (figure 4). The excessive soil erosion covers the largest areas of over 260 ha, especially hillslopes exceeding 18%.

The maximum development of soil erosion on agricultural land is stretching on 3,402 ha comprising slopes between 9-18%.

The characteristics of the soil types from the Stavnic catchment are connected with the intensity of soil erosion (figure 5). The most affected soils by erosion are the wooden soils, represented by Preluvosols (1,859 ha) and Luvosols (1,323 ha), followed by Chernozem (1,410 ha) and Phaeozem (1,994 ha). The very severe and the excessive erosion is typically to Anthrosols (715 ha) and Regosols (232 ha), which highlights the intensity of the soil erosion within the study area.

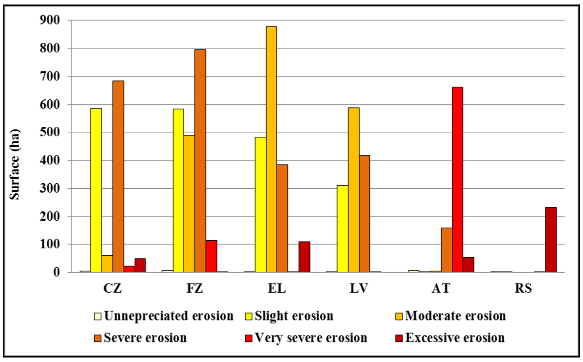

Fig. 5. Distribution of the soil erosion intensity classes on agricultural land by soil types (processing of O.J.S.P.A. Iasi and Vaslui soil surveys)

2.2. Gully erosion. Gullying has a secondary role within the Stavnic catchment, without reaching the highest values from other areas within the Barlad Plateau. A number of 330 gullies have been inventoried in the study area and they

Table no. 1. The area under gullies within the Stavnic catchment

Gullies	Number	The area occupied by gullies		
		ha	% of the catchment	% of the total gullied area
Valley-bottom gullies	25	187,6	0,9	22,8
Valley-side gullies	305	635,9	3,0	77,2
Total	**330**	**823,4**	**3,9**	**100,0**

cover 823 ha, representing 4% of the total area (figure 6). Valley-side gullies are the most widespread and occupy 636 ha (77%), compared to the valley-bottom ones with only 188 ha and weighing 23% of the total gullied area (table no. 1). Furthermore, over half of the gullied area is under forest, reaching 433 ha.

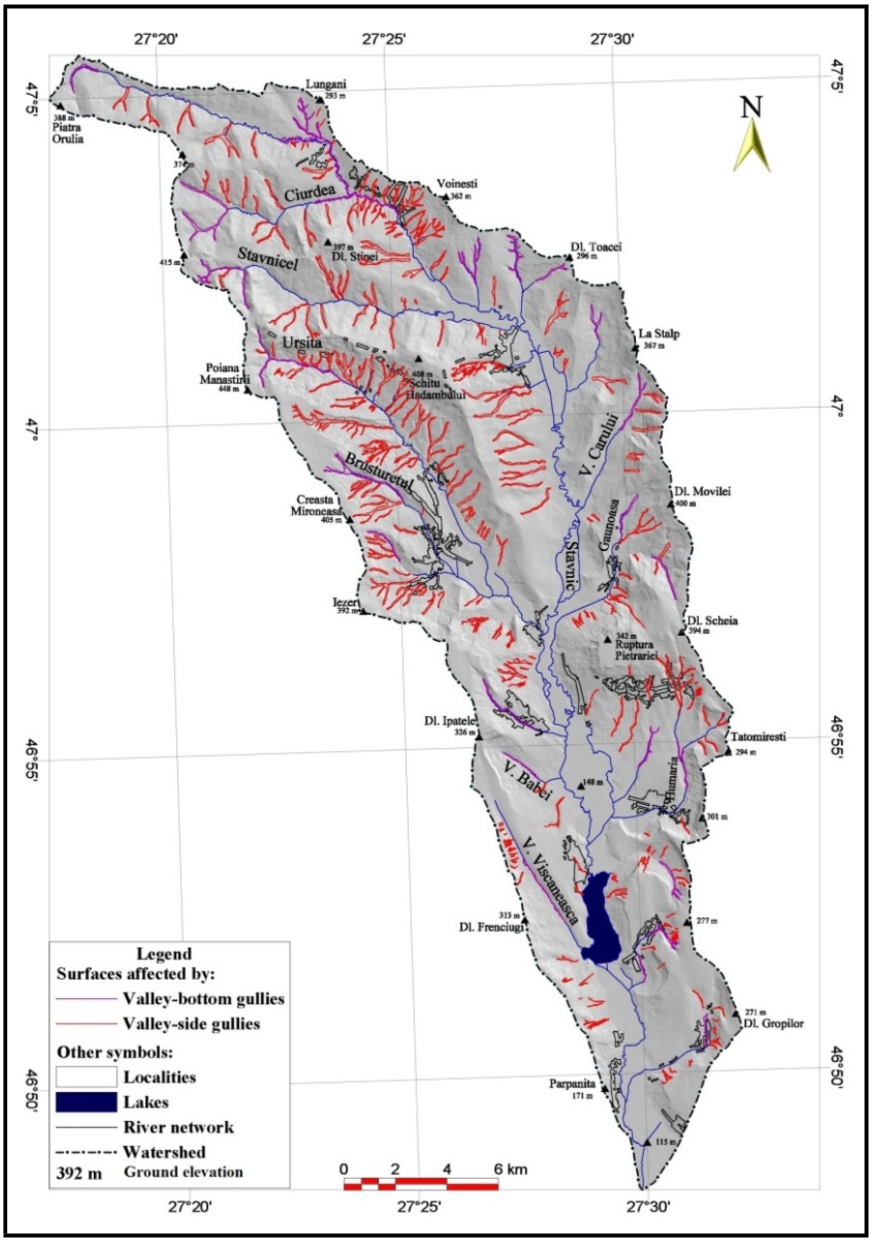

Fig. 6. Gully distribution in the Stavnic catchment

The significant frequency of the valley-side gullies is due to the human impact, associated to inadequate road network and the traditional up and down hill farming (Niacsu L., 2009).

On gentler slopes, under 5%, the valley-bottom gullies are extending on 39 ha, weighing almost 20% of the total valley-bottom gullies area (figure 7). About 86% of the total valley-side gullies are identified on slopes exceeding 9% and they cover 548 ha.

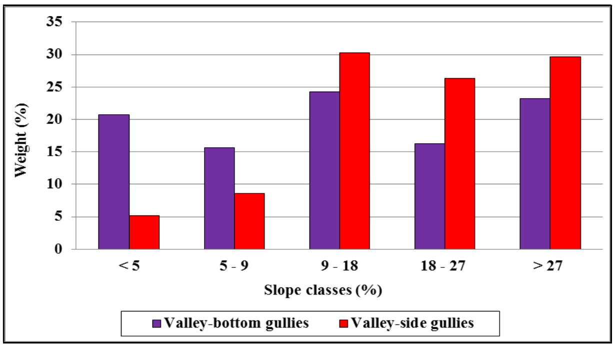

Fig. 7. Distribution of the gullies by slope classes

In addition, 43% of the valley-side gullies are extending on the cuesta fronts and 33% on the highly degraded cuesta back slopes (figure 8).

Also, 40% of the valley-bottom gullies occur especially on flatter land, such as floodplains, fluvial terraces and glacises.

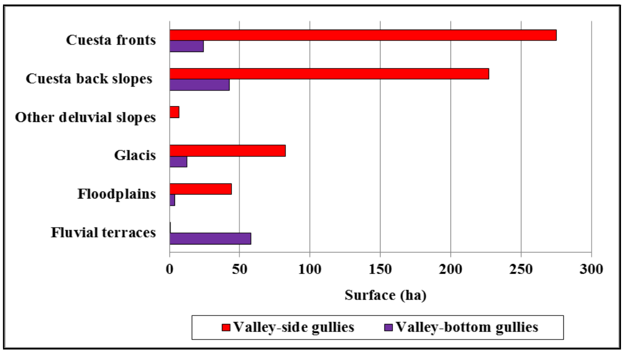

Fig. 8. Distribution of the gullies by landforms

2.3 Landslides. The most important geomorphic process which affects the land from the study area is represented by landslides. They "*are natural movement of the rock masses on slopes, involving water under the action of gravity*" (Donisa

I. et. al., 2009). They are extending on 12.006 ha, which represents 56% of the total area (Puflea Suzana Mirela, 2014). This value is higher than the average weight of 47.3% typical for the entire Central Moldavian Plateau as calculated by Ionita et al (2014). Such a larger and significant landslide extension is mainly associated to the more dissected local topography of the Stavnic catchment.

Morphologically, the waves-like shape landslides are prevailing, followed by steps-like ones and the complex landslides.

Most of the landslides are stabilized and these occupy 11,624 ha (97% of total), while the active ones cover only 382 ha (3%). One mention must be made, that the active landslides showed a much greater extension during the last century, mostly after 1968-1973 period that received more precipitation (Ionita I., 2000a). Since summer 1982, in the context of climate aridisation, many active landslides have turned stabilized.

Around 93% of landslides occur on slopes over 9% (figure 9). Thereby, 31% of the active landslides (118 ha) cover valley-sides where the slope values exceed 27%. Of the total stabilized landslides, an area of 4,872 ha (weighing 42%) develop on slopes between 9-18%, including the highly degraded cuesta back slopes, too (Puflea Suzana Mirela, 2014).

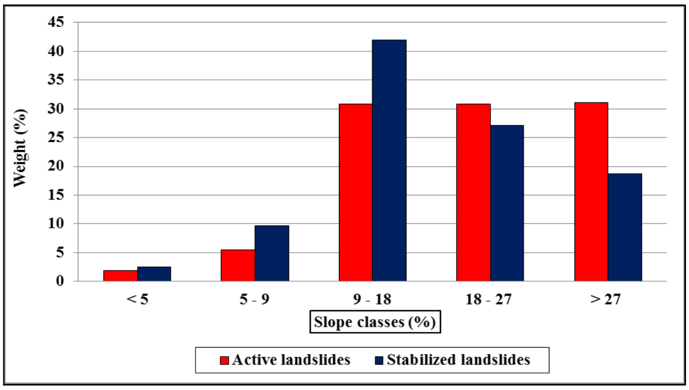

Fig. 9. Landslides distribution by slope classes

Figure 10 illustrates the areas occupied by the landslides depending on the exposition of the land. Most of the landslides are prevailing on the northern and western generally facing cuesta fronts (Ionita I. 2000a). For example, 23% (87 ha) of the active landslides, and 18% of the stabilized landslides (2,079 ha) have been identified on the north-eastern looking slopes from the Stavnic catchment.

Also, a significant share of the landslides develop on the predominantly southern (19% or 1,270 ha) or eastern (36% or 1,806 ha) looking slopes, which represent cuesta back slopes. Those landslides are mainly triggered by deepening and meandering of the river channel and slope undermining (Puflea Suzana Mirela, 2014).

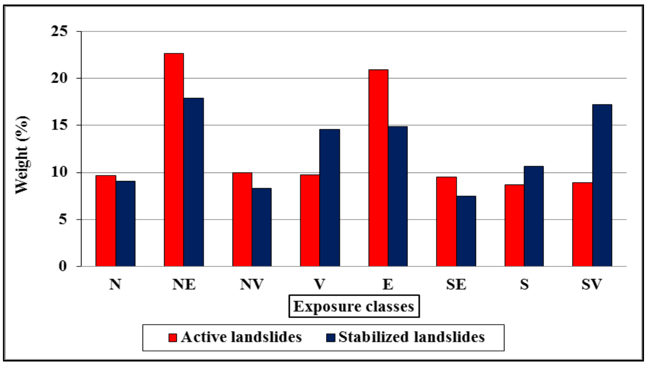

Fig. 10. Landslides distribution by exposure classes

By landforms, the largest areas subjected to landslides are the cuesta fronts (7,102 ha) and the highly degraded cuesta back slopes of 3,741 ha (figure 11). Therefore, landslides occurrence is strongly connected to the northern facing cuesta fronts (4,656 ha) compared to the western looking cuesta fronts (2,446 ha). In turn, the glacises, the structural-lithological plateaus, the hilltops and the fluvial terraces are very slightly subjected to landslides.

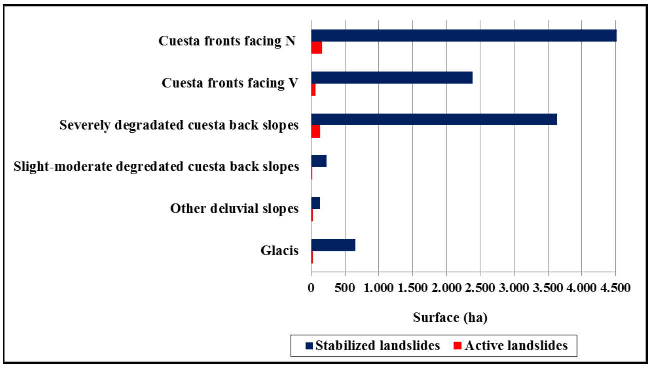

Fig. 11. Landslides distribution by landforms

2.4. Sedimentation. Another present day geomorphic process in the studied area is reservoir sedimentation. According to Ionita I. et al. (2000b), by using the Cs-137 technique it was calculated an average sedimentation rate of 4.5 cm yr^{-1} for the period 1975-1999 in the Cazanesti reservoir, located in the lower Stavnic.

The Cs-137 depth distribution shows the 1986 peak of 34.7 Bq/kg is located at 45-50 cm depth (figure 12). Taking into account the severe drought over the period

1986-1987 without significant stream-flows, it is obviously the strong impact of woodland area upon this distribution resulting in both a two years delay of the main Cs-137 peak (57.0 Bq/kg at 35-40 cm due to extremely rainy spring 1988) and a very low Cs-137 concentration above in the top 30 cm. This time, there is a fairly significant difference in sediment deposition if comparing mean annual rates over the period 1975-1985 of 5.2 cm yr^{-1} to 1986-1998 of 3.85 cm yr^{-1} (Ionita I. et al., 2000b).

This relatively high mean value is closely related to a series of features of the local landscape, especially the relief fragmentation, the clayey-sandy lithology and the considerable degree of forestation.

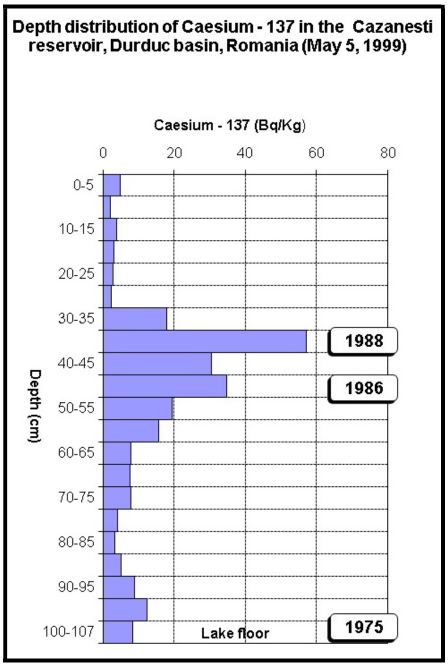

Fig. 12. Distribution on the profile of Cs-137 in the Cazanesti reservoir (Ionita I., 05 May 1999)

Conclusions

The most representative land degradation processes within the Stavnic catchment are the landslides which cover 12,006 ha representing 56% of the total surface. About 97% (11,625 ha) of the area under landslides are stabilized, while the active ones are extending on 382 ha (3%).

Soil erosion occurs under different intensities on the slopes exceeding 5%.

The area of 823 ha under gullies (4% of the catchment) is relative small, but the high number and density of gullies are in the favor for triggering mass movements on large areas.

By using the Cs-137 technique, within the Cazanesti reservoir it was calculated an average sedimentation rate of 4.5 cm yr^{-1} over the period 1975-1999.

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