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SOIL EROSION AND GULLYING WITHIN THE STAVNIC CATCHMENT

Suzana-Mirela Puflea[1] Ion Ioniță[2]

Abstract. The Stavnic catchment located in the Central Moldavian Plateau is 21,341 ha in size. The typical hilly landforms, the interaction between the natural factors, namely the alternation of permeable and impermeable rocks (clays, sands, loess-like deposits), the markedly fragmentation of the topography and the influence of the anthropogenic factor as well have triggered the acceleration of the land degradation processes from the study area. Among these, the most important include soil erosion, gully erosion, landslides and sedimentation of floodplains.

Soil erosion represents the geomorphic process with the highest distribution extending on about 41% from the entire catchment. This process occurs particularly on slopes exceeding 5% and the average annual soil loss on the agricultural land was estimated at 22.15 t ha^{-1} yr^{-1}.

The area under gullies is 823 ha (4% of the total area), and gullying seems to have a secondary role within the Stavnic catchment. Apparently, the weight of gullies is a reduced one, but their number and density are high, which favors triggering of mass movements on large areas.

Keywords: Central Moldavian Plateau, soil erosion, gullying, sedimentation

1. Introduction

The Stavnic catchment extending in the central part of the Central Moldavian Plateau occupies 21,341 ha, representing 6% of the total. Northwards, it is confined by Coasta Iasilor. Eastwards, it is bounded by the Rebricea catchment and westwards by the Sacovat catchment. The Stavnic River springs from Grindei Hill, downstream of Padureni village, Iasi County and it merges the Barlad River south of Parpanita village.

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 (climatic, hydrologic, biotic and soil factor), plus the negative anthropogenic influence through deforestation, expansion of settlements, inadequate road network and inappropriate agricultural practices (Bacauanu V. et al., 1980).

In this area the clayey-sandy Miocene layers belonging to the Middle Sarmatian (Bessarabian) and Upper Sarmatian (Chersonian) have outcropped due to erosion. In addition, the recent Quaternary formations are mentioned. The Bessarabian deposits are prevailing, highlighted in the relief in the form of structural plateaus grafted onto the calcareous-

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sandstone cap resistant layer. The Chersonian clayey-sandy layers are discontinuously extended on the higher hilltops, in the form of erosion remnants (Jeanrenaud P., 1961, 1971, 1995).

The landforms from the Stavnic catchment are typical hilly peculiar to the Central Moldavian Plateau, in which the sculptural (fluvio-denudational) topography in general monocline structure (homocline) is the dominant type of relief. The valley-sides occupy most of the area and frequently they depict either cuesta fronts or cuesta back slopes.

Most of agricultural land is mantled by Cernisols (4,487 ha), Luvisols (2,716 ha) and Aluvisols (2,232 ha). Also, the significant areas covered by Anthrosols (918 ha) and Regosols (244 ha) suggest the high intensity of soil erosion.

2. Material and methods

In recent years, the classical research methods have been improved by information technologies that have entered in all fields, including Geography. Thus, in the analysis of the present day geomorphic processes within the study area the TNT Mips v.6.9 software was used and statistical basis was processed by using Microsoft Office Excel 2010.

The setting and delimitation of areas affected by soil erosion and gullying within the Stavnic catchment were made through the correlation of the field observations, geomorphological survey and the interpretation of the color aerial photos delivered in 2009. An important first step in the scientific approach was the achievement of the Digital Elevation Model (MNT), obtained by digitizing and vectorization of the topographical maps at the scale 1:5,000. On this base, a series of thematic maps have been released (slope map, shape map, shading map) and they were classified through SML language (Puflea Suzana Mirela, 2014).

Soil erosion has been estimated firstly in terms of qualitative approach, by data processing from the soil surveys at scale 1: 10,000 undertaken by OJSPA Iasi and Vaslui. Secondly, the main focus of this study refers to the quantitative approach which consisted in estimating the average annual soil losses on agricultural land by applying the Motoc model (1975, 1979) through the adaptation of USLE to the conditions from our country.

3. Results and discussions

3.1. Soil erosion

The geological substratum, the geomorphological, climatic and hydrological characteristics, as well as the anthropic impact have triggered the extension of soil erosion on large areas. This geomorphic process covers 8,655 ha, weighing 41% of the surveyed area. The remaining area of 12,685 ha (59% of total) is under non-agricultural land as forests (40%), villages and lakes.

The map showing intensity of soil erosion on agricultural land was obtained by digital processing of information from the soil surveys at scale 1: 10,000. These have been carried out by OJSPA Iasi and Vaslui, and partially adjusted according to our field observations and the orthophotos (Figure 1). Then, the average annual soil losses from the Stavnic catchment were estimated more accurately by using Motoc model (Figure 2).

By processing data from the soil studies on agricultural land it has been noticed that almost a quarter of the surveyed area is depicted by unappreciated soil erosion and the land under moderate to excessive erosion comprises half of the total (52%).

The average annual soil losses on the agricultural land, derived by using the Motoc model, were estimated at 22.15 t ha^{-1} yr^{-1}. About 3,356 ha (39%) from the surveyed area has an average value of erosion below the annual tolerable limit of 7 t ha^{-1} yr^{-1}. Higher values were calculated for 5,230 ha, respectively over 60% of the total agricultural land within the Stavnic catchment.

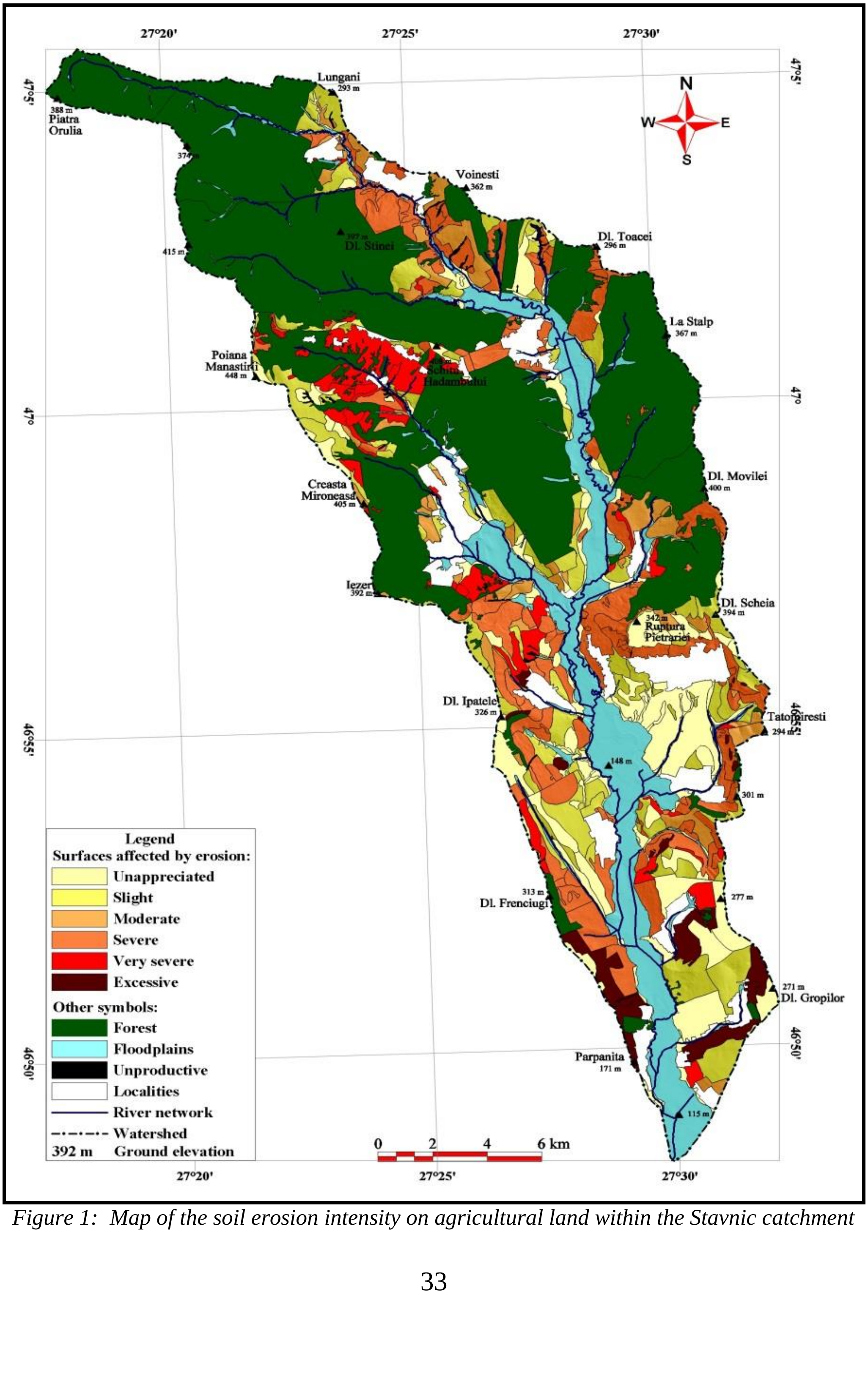

Figure 1: Map of the soil erosion intensity on agricultural land within the Stavnic catchment

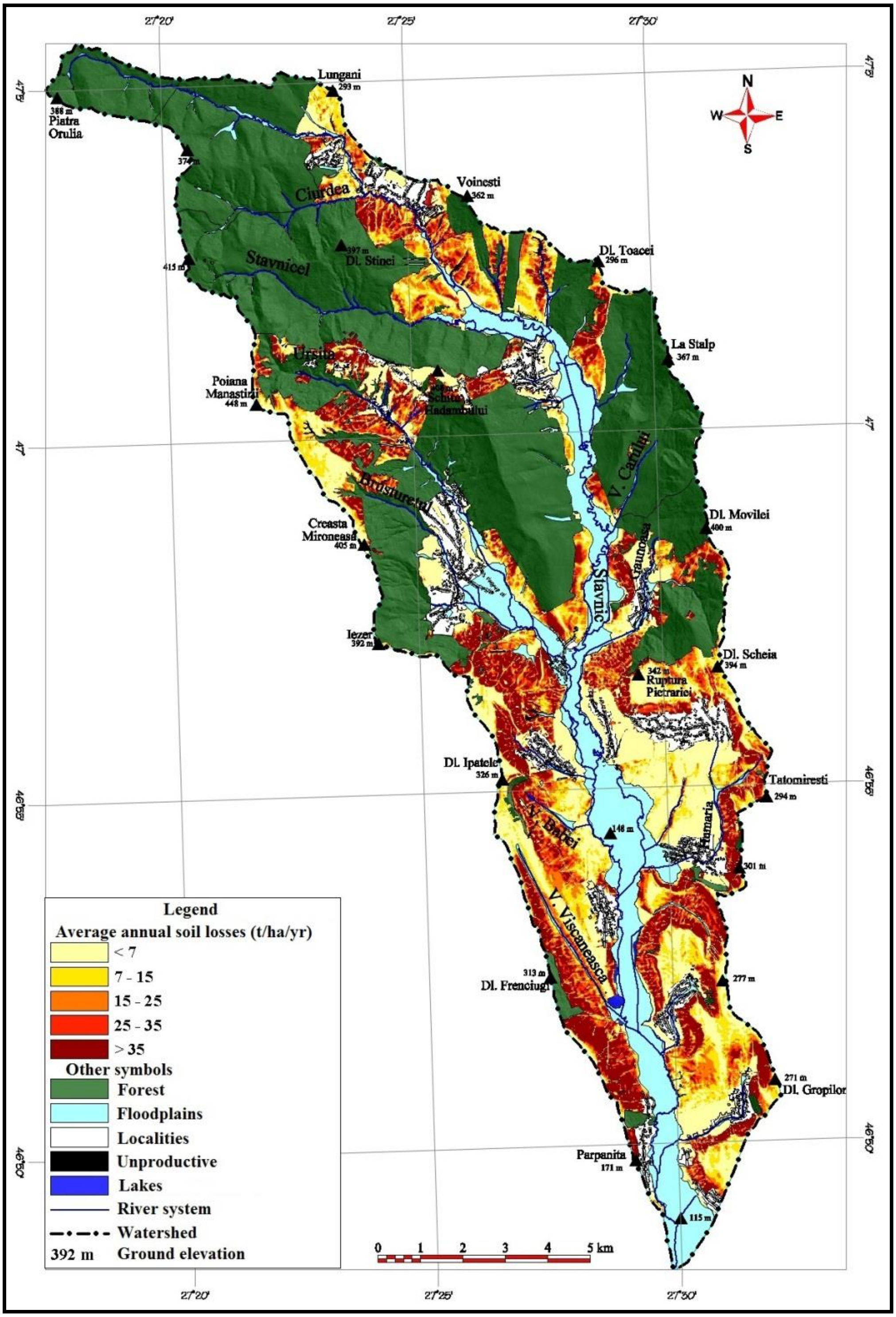

Figure 2: Map of total erosion on agricultural land with erosion potential within the Stavnic catchment

The highest values of soil erosion correspond to the northern looking cuesta fronts (40 t ha^{-1} yr^{-1}) or the western facing cuesta fronts (37 t ha^{-1} yr^{-1}), other deluvial slopes (34 t ha^{-1} yr^{-1})

and highly degraded cuesta back slopes (23 t ha^{-1} yr^{-1}), due to the steeper slopes and the traditional up and down hill farming (Figure 3). Values below the average annual soil loss of 22.15 t ha^{-1} yr^{-1} are typical to glacises (11 t ha^{-1} yr^{-1}), structural-lithological plateaus (9 t ha^{-1} yr^{-1}), slightly-moderate degraded cuesta back slopes (9 t ha^{-1} yr^{-1}) and floodplains (6 tha^{-1} yr^{-1}).

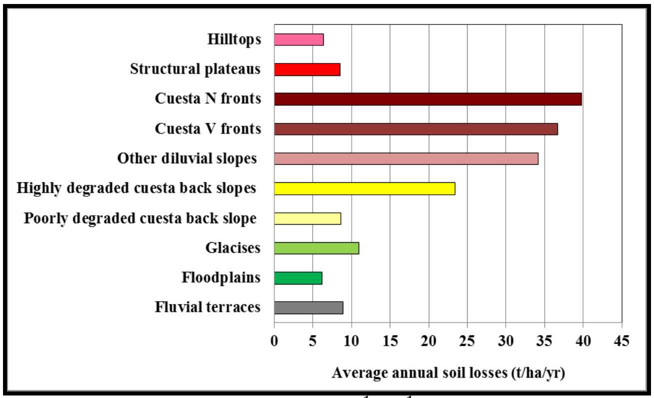

Figure 3: The average annual soil losses (t ha^{-1} yr^{-1}) on agricultural land by landforms

Figure 4 shows the relation between the average soil losses on agricultural land (t ha^{-1} yr^{-1}) and the main soil types. The more intensely eroded soils are the Regosols (51 t ha^{-1} yr^{-1}), the Anthrosols (42 t ha^{-1} yr^{-1}) and the Phaeozems (23 t ha^{-1} yr^{-1}).

Also, the wooden soils present significant values of soil erosion, namely Preluvosols (20 t ha^{-1} yr^{-1}) and Luvosols (16 t ha^{-1} yr^{-1}). The Gleiosols (7 t ha^{-1} yr^{-1}) and the Aluviosols (5 t ha^{-1} yr^{-1}) are slightly eroded.

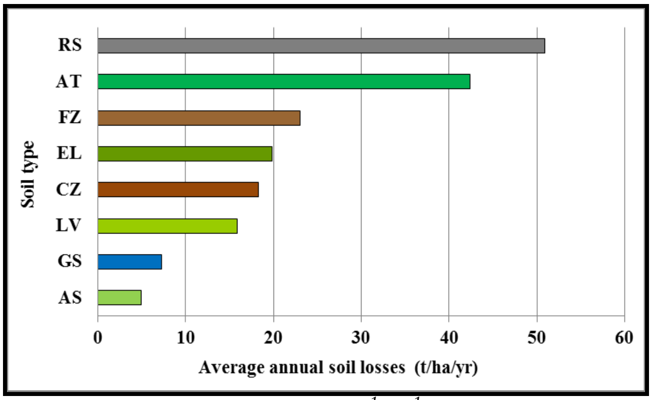

Figure 4: The average annual soil losses (t ha^{-1} yr^{-1}) on agricultural land by soil type

Figure 5 illustrates that the highest soil losses due to soil erosion are recorded on degraded vineyards (48 t ha^{-1} yr^{-1}), followed by degraded orchards (46 t ha^{-1} yr^{-1}) and degraded pastures (32 t ha^{-1} yr^{-1}). Lower values could be noticed on arable land (19 t ha^{-1} yr^{-1}) and orchards (17 t ha^{-1} yr^{-1}).

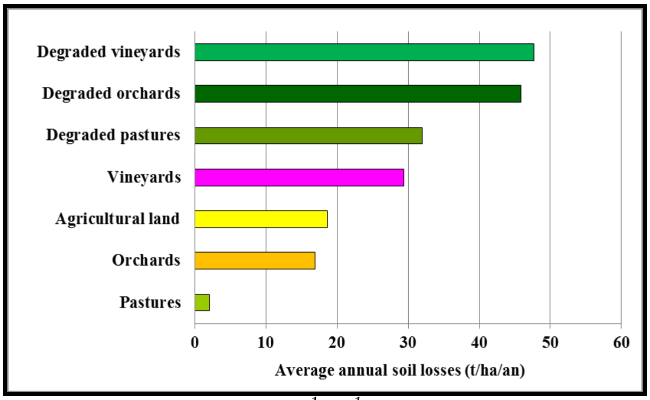

Figure 5: The average annual soil losses (t ha^{-1} yr^{-1}) on agricultural land by land use categories

3.2. Gully erosion

A number of 330 gullies, occupying 823 ha, respectively 4% of the Stavnic catchment have been identified based on the field observations, information from both the orthophotos and the topographical maps. Numerically, valley-side gullies are prevailing (305 gullies), which are usually discontinuous, single and rarely successive. The 25 valley-bottom gullies are much more developed and are included in the class of continuous gullies (Ionita I., 2000a).

Figure 6 depicts the relation between gullying and the land orientation classes.

The valley-bottom gullies occur particularly on the south-western (18%), south (17%) and south-eastern facing land (15%), which usually represents cuesta back slopes. Also, the valley-bottom gullies develop on western (12%), north-eastern (11%) and north-western looking slopes (7%), which correspond to cuesta fronts.

In turn, the valley-side gullies occurs on large areas on south-eastern (16%), eastern (14%), south and south-western (13%) looking slopes with role of cuesta back slopes. On the other hand, these have significant weights on west (13%), north-east and north-west (11%) facing slopes, such as cuesta fronts.

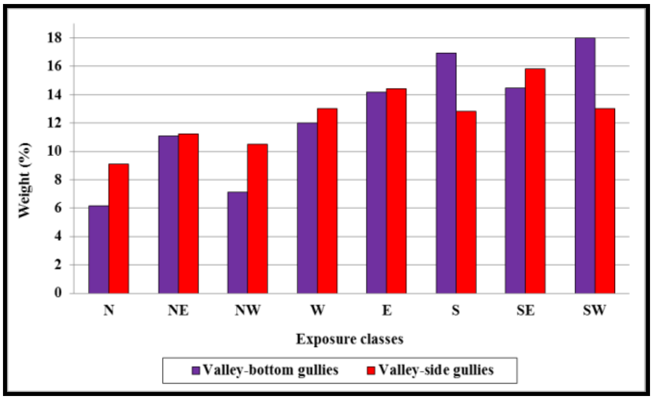

Figure 6: The gully distribution by exposure classes

Ionita I. (1998, 2000a, 2007c) established that the gullying critical season lasts four months between 15-20 March to 15-20 July. The most important role falls to the cold season (57%), especially due to the impact of freeze-thaw cycles, and the warm season ranks the second position with a weight of 43%.

Figure 7 illustrates the distribution of gullies by land use categories within the Stavnic catchment. The most important areas incised by valley-side gullies are found under forests (341 ha), degraded pastures (72 ha), transitional woodland-shrub (62 ha). The valley-bottom gullies are mostly common in the areas under forests (92 ha) and degraded pastures (30 ha).

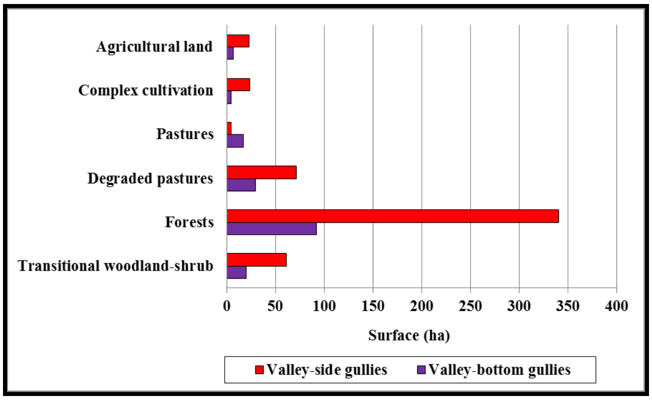

Figure 7: Distribution of the gullies by land use categories

3.3. Floodplains sedimentation

Besides typical land degradation processes, the sedimentation is of interest, too. The analysis of floodplain sedimentation rate in the Cazanesti reservoir, located in the lower Stavnic was calculated by using the Cs-137 technique. Ionita I. et al. (2000b, 2007b) have estimated an average sedimentation rate of 4.5 cm yr^{-1} over the period 1975-1999. The mean sedimentation rate was 5.2 cm yr^{-1} between 1975-1985 and later decreased to 3.85 cm yr^{-1}.

The Cs-137 depth distribution on the profile of the Cazanesti reservoir indicates two peaks, one in 1986 (34.7 Bq/kg) associated to the Chernobyl nuclear accident and another one in 1988 associated to a rainy year. The second and the most important peak (57.0 Bq/kg) highlights the strong buffer impact of the sizeable woodland area (8,304 ha) from the Stavnic catchment.

The relatively high mean value of reservoir sedimentation is closely related to a series of features of the local landscape, especially the markedly relief fragmentation, the clayey-sandy lithology and the high degree of forestation (39% from the catchment area upstream the Cazanesti reservoir).

Conclusions

Soil erosion and gullying are the most important land degradation processes within the Stavnic catchment. Their development and distribution are strongly related to the characteristics of the present day topography (slope, land orientation, hypsometry, relief fragmentation, landforms, etc.) as well as the land use. The highest land degradation occurs on slopes with role of cuesta fronts and on the highly degraded cuesta back slopes.

Based on the Motoc model, the average annual soil loss on the agricultural land was estimated at 22.15 t ha^{-1} yr^{-1}.

Gully erosion although presents a restricted weight is in the favor of triggering mass movements on large areas.

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