LAND DEGRADATION PROCESSES IN THE UPPER CATCHMENT OF CRASNA RIVER

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Abstract. The paper proposes the study of land degradation processes in the upper catchment of Crasna River and also the controlling factors, the differentiation of the main degradation processes, their distribution and intensity, the evaluation of the impact over the environment and eventually, it establishes some soil conservation practices. The cumulated action of natural factors, especially the coupling of Chersonian sandy-clayey facies-hilly fragmentation and of the anthropogenic ones favoured for triggering degradation processes. Among these, the most common include soil erosion, gullying, landslides and sedimentation of floodplains. Soil erosion occurs with different intensities on the lands with slopes over 5% and represents the process with the highest extension. Landslides are the most representative geomorphologic processes in the study area. They have a weight of 28.6% of the total area, affecting particularly very steep slopes, usually with a role of cuesta front, but most of them are old landslides. The recent period of maximum rainfall in the Moldavian Plateau, 1968-1973, caused significant reactivation of landslides. Gradually, since 1982, in the context of long-term climate, increased aridity indicates the prevalence of stabilized landslides. Locally, numerous valley-bottom gullies and valley-side gullies (some with an impressive growth) occur in bedrocks with loose, sandy and sandy-loamy layers. Through soil erosion, gullying and landslides, significant quantities of solid material are being carried to the base of slopes although the average rate of sedimentation in reservoirs remains low.

Keywords: *landslides, soil erosion, gullying, sedimentation*

1. Introduction

The analysis of land degradation processes represents a current problem, both at the national and international level, holding a great importance in studying landscape dynamics in hilly regions.

Geomorphological, land degradation represents the "*destructive action of risk geomorphological processes (soil erosion, gullying, landslides, sedimentation) through which occurs a reduction in the relief height, which leads to the removal of some lands from the economic circuit*" (*Donisa et al., 2009).*

The upper catchment of Crasna River is among the regions heavily subjected to land degradation. It is located in the eastern edge of Central Moldavian Plateau, on an area of 22,076 ha, which represents 41% of the total surface of Crasna basin (Figure 1).

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From a territorial and administrative point of view, the studied area is situated within two counties, Iasi and Vaslui, partially overlapping over territory of Ciorteşti, Moşna, Schitu Duca, Coştuleni, Răducăneni, Dolheşti, Cozmeşti, Arsura, Micleşti, Boţeşti, Buneşti-Avereşti, Tătărăni and Soleşti villages.

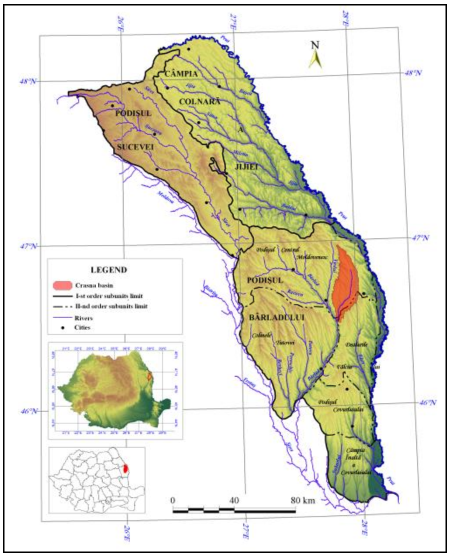


Figure 1: Geographical location of upper catchment of Crasna River

2. Materials and methods

In the last few years, due to the development of some performing GIS software, the analysis of land degradation has become easier, allowing the creation of consistent databases, operated easily and quickly. In order to reach the objectives we used both traditional methods specific to geographical researches (analysis, synthesis, mathematical-statistical processing, field observations and mapping) and modern methods based on the use of GIS software.

Mostly, the cartographic material was obtained using TNTmips v.6.9 software and statistical basis was processed using Microsoft Office Excel 2007.

A very important step in spatial modelisation of land degradation consisted in achieving the Digital Elevation Model, obtained by vectorizing contours lines on 1:5.000 scale topographic plans. Using this, a series of thematic maps (hypsometric, slope, slopes exposition, drainage depth) were realized in order to analyse the land degradation processes.

The right approaching and understanding of degradation processes requires consideration of the controlling factors influence. For this purpose the following data were used:

- Geological map of the central part of Moldavia between Prut and Siret (P. Jeanrenaud, 1971);
- Climate data from weather stations Vaslui, Huşi, Bârnova, Negreşti;
- Data recorded at hydrometric stations Mânjeşti and Vineţeşti;
- Pedological studies for Ciorteşti, Moşna, Schitu Duca, Coştuleni, Răducăneni, Dolheşti, Cozmeşti, Arsura, Micleşti, Boţeşti, Buneşti-Avereşti, Tătărăni and Soleşti municipalities;
- Corine Land Cover 2000 and aerial orthophotos from 2005 to identify geomorphological processes and to highlight the land use.

Surface erosion map was made using data on the intensity of soil erosion, from soil studies at scale 1:10,000 and the map of gullies and landslides distribution resulted from the combination of data collected during field stage with the one taken from orthophotos.

3. Land degradation processes

Along with droughts, floods and earthquakes, the range of natural hazards from Crasna catchment is completed by land degradation processes, namely soil erosion, gullying, mass movements (fallings and landslides) and floodplains sedimentation.

3.1. Soil erosion

Among degradation processes, the largest spatial extension submits to soil erosion, affecting 91% of the total area of the catchment. This consist in the displacement of soil and/or rock particles as a result of water erosion, both through rainsplash and by runoff as dispersed and concentrated currents.

Along with the saturation of soil in water, its infiltration capacity decreases, so that water begins to accumulate in the form of small streams (trickles), generates rills and carry the eroded solid material to the base of slopes, which creates colluviums and colluvial glacises (Figure 2).

Figure 2: Rill erosion in Beneşti Hill, on the left slope of Seaca Valley (8.05.2012)

The noticeable development of soil erosion in the upper catchment of Crasna is due to the fulfilment of some favourable natural conditions (predominantly Chersonian loose sedimentary layers, widespread of the steep slopes, heavy rain falls, low density of vegetation, soils with light texture and low organic matter content etc.), plus inappropriate land use.

The map from Figure 3 gives us an image about the spatial distribution and about the intensity of surface erosion on agricultural land occupying 62.8% of the studied area. This map was made by processing information obtained from soil surveys for municipalities within the analysed basin. In differentiating the erosion classes there were taken into account the morphologic characteristics of soils, and also the thickness of genetic horizons, according to the classification proposed by Moţoc M. (1963).

Data from statistical processing of surface erosion intensity map on agricultural lands are given synthetic in table no. 1.

Of the 13,872.5 ha of agricultural land, the largest weight is held by land with unappreciated erosion (42.7%), followed at considerable distance by the slightly eroded soils

(21.3%), severe (12.9%) and moderate erosion (11.5%). At the opposite pole there are the classes with excessive erosion with 7% and very severe, with only 4.6% of the surveyed area.

The remaining of 8,203.4 ha represent non-agricultural areas (forests, localities, lakes, etc.), without direct observations about the surface erosion. The intensity of soil erosion occurs differentially by landforms. Thus, the most affected are the western and northern exposed cuesta fronts, plus some highly degraded backslopes. A lower intensity is recorded on floodplains, hilltops, glacises and alluvial fans (Figure 4).

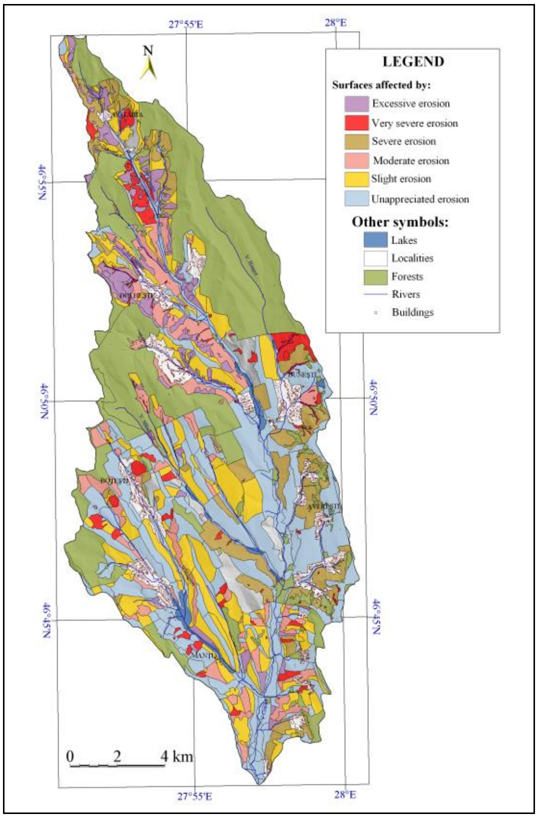


Figure 3: The map of soil erosion intensity on agricultural land within the upper catchment of Crasna (Processing after pedological surveys of OJSPA Vaslui and Iaşi)

Table 1: The surface erosion intensity on agricultural land in the upper basin of Crasna

Soil erosion classes	**Surface (ha)**	**Weight (%)**
Unappreciated	5.917,5	42,7
Slight	2.958,3	21,3
Moderate	1.595,2	11,5
Severe	1.794,5	12,9
Very severe	636,8	4,6
Excessive	970,3	7,0
Total	**13.872,6**	**100**

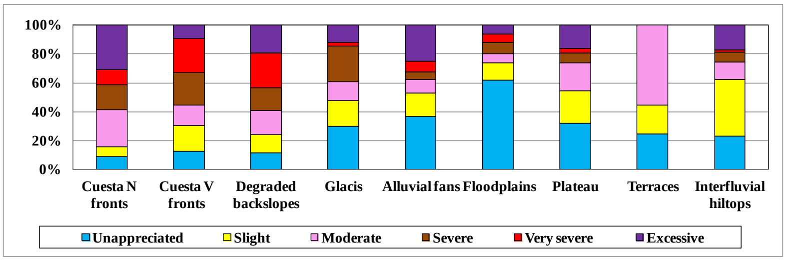


Figure 4: The distribution of soil erosion intensity classes on agricultural land by landforms

The intensity of surface erosion increases with slope inclination value. On the lands with slopes less than 10% prevails the unappreciated erosion, those with slopes between 10-25% show a specific low-moderate erosion, while lands with slopes over 25% have relatively equal weights of powerful, very powerful and excessive erosion (Figure 5).

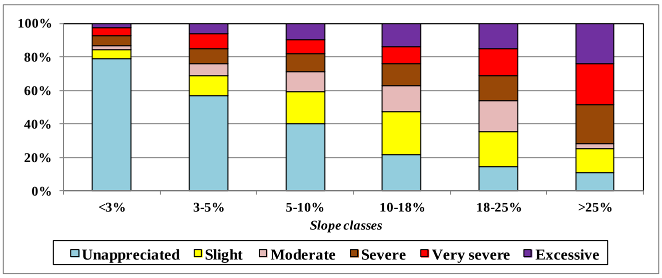


Figure 5: Classes of soil erosion intensity versus slope on agricultural land

Unlike gully erosion and landslides, soil erosion is more difficult to be observed in space, being noticeable particularly in spring and autumn when the degree of soil coverage by vegetation is reduced. However, on long term it reduces soil fertility and thus lowers the level of agricultural yield, which is particularly serious if we consider that agriculture is the main source of income for the local population.

The least affected soils by erosion are stagnosols, pelosols, gleiosols, fluvisols and eutricambosols, at the opposite pole being situated psamosol, regosols and anthrosols (Figure 6).

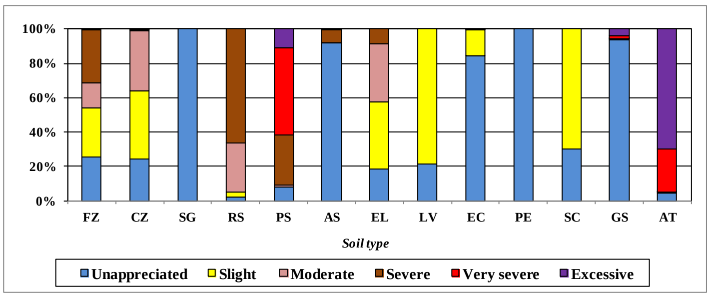


Figure 6: Classes of soil erosion intensity versus soils on agricultural land

Vegetation plays a critical role in conditioning the surface erosion. Depending on the density and stage of growth, it retains a significant amount of water from precipitation and reduces impact of raindrops over the soil. The best protection is ensured by natural vegetation, especially forests and meadows, while among the cultivated plants, perennial grasses and closed growing crops are good protectors and row-spaced crops are weak protectors.

The intensification of soil erosion is accelerated also by irrational land use, especially by up-and-down hill farming, with a high percentage of row-spaced crops.

The highest rates of surface erosion are recorded on arable land with considerable slopes, especially those cultivated with row-spaced crops and heavily degraded grasslands due to over-grazing. Low values of erosion occurred in forest, improved pastures and arable land under conservation practices (Figure 7).

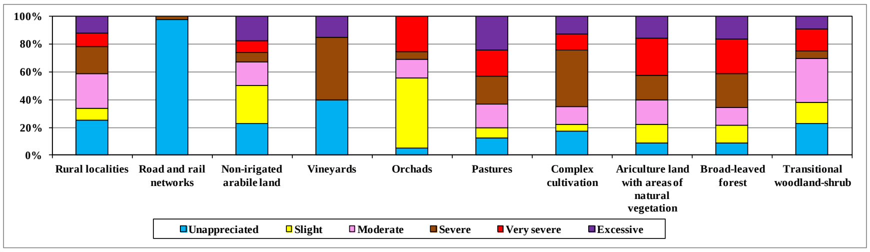


Figure 7: Classes of soil erosion intensity versus land use on agricultural land

Soil erosion can be prevented and controlled through widespread implementing of a complex of agro-technical and ameliorative measures that should reduce water and soil losses. By applying the provisions of the Law no. 18/1991 of Land Inventory, the agricultural land were returned to former owners, usually on old locations, as small up-and-down plots, leading to almost complete destruction of the existent conservation practices.

However, in the last few years there have been made fusions of land, by founding associations or by taking on lease, so that on those areas mechanized agricultural work can be deployed on the contour, maintaining previous conservation systems, namely strip-cropping, buffer-strip cropping and bench terraces or combined, such as those on the slopes of the Balcu, Blăgeşti and Mândreşti valleys (Figure 8).

Figure 8: Bench terraces on the left valley-side of Mândreşti Valley, in Găneşti Hill (17.09.2012)

The study of soil erosion by using the runoff plots at SCCCES Perieni, in the Ţarina Valley, Tutova Rolling Hills, allowed to Ionita I. (1985, 1990, 1995, 1998, 2000, 2007) to determine the length of the critical season of soil erosion at two months between 15-20 May to 15-20 July. The same author points out that the cambic-chernozem from Perieni - Bârlad Station is characterized by high resistance to erosion, which explains the low average annual value of 7.74 t / ha of soil erosion under maize. Therefore, on the highly eroded forest soils the value of soil loss is double and on the land with similar slope, the value of annual average erosion fluctuates around 15-16 t/ha.

3.2. Gully erosion

The most developed forms of erosion are the gullies which represent channels resulted from concentrated flow during heavy rainfalls or snowmelt (Poesen J., Grovers G., 1990). They are stretching mostly on steep slopes, slightly covered by vegetation, developed on a sandy-clayey substratum. Figure 9 shows the distribution of the gullies in the upper catchment of Crasna and the area occupied by gullies is 214 ha, which represents 1% of the total.

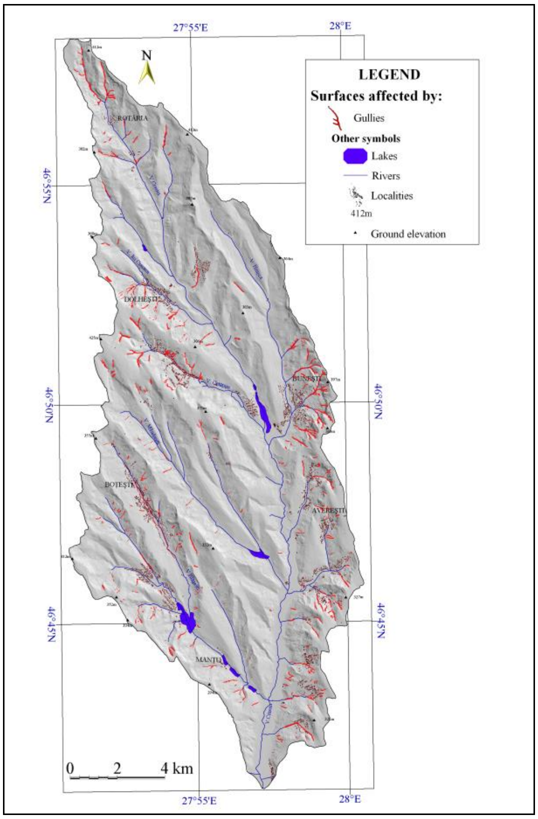


Figure 9: The gully distribution in the upper catchment of Crasna River

Depending on their position within the basin, the gullies can be divided into valley-side gullies and valley-bottom gullies. Valley-side gullies are the most numerous and generally smaller, while valley-bottom gullies are greater and have a faster evolution (Figure 10).

Depending on the land use, most gullies are found in forests, especially under the false-acacia plantations, established 40-50 years ago (28.7%), on agricultural land mixed with natural vegetation (16.2%), in localities (12.8%), on arable land (12.2%) and 11.2% on complex agricultural land (Figure 11).

Figure 10: Valley-side gully in the Cerului Hill, at north-west of Dolheşti village (15.09.2012)

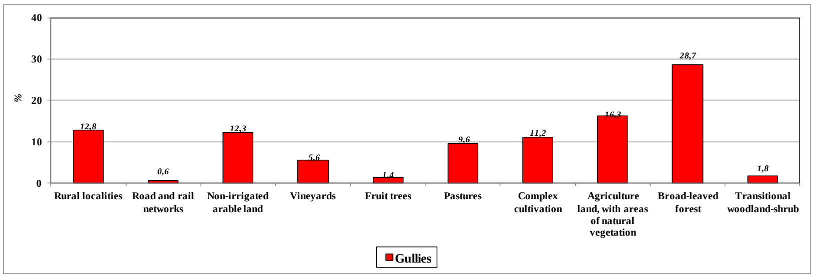


Figure 11: The distribution of gullies by land use categories

Figure 12 clearly suggests predominant distribution of gullies on cuesta front slopes (71.3%), followed by the gullies developed on the cuesta backslopes (21.6%).

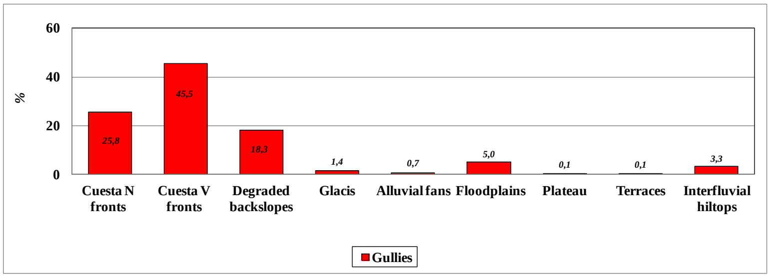


Figure 12: The gullies distribution by land forms

Ionita I. (1998, 2000, 2007) by studying the annual regime of six continuous gullies from Bârlad Plateau, during 1981-1996, established that the gullying critical season lasts four months, from March 15- 20 – 15-20 July.

3.3. Mass movements

In the category of mass movements, in the upper catchment of Crasna River, a particular interest is presented by landslides that through their size, dynamics and created landforms, are the most representative degradation process.

Map from figure 13 shows that they occupy 6,566.5 ha, representing 28.6% of the studied area. Most are old and stabilized (97%) landslides, and only a small part can be included as active ones.

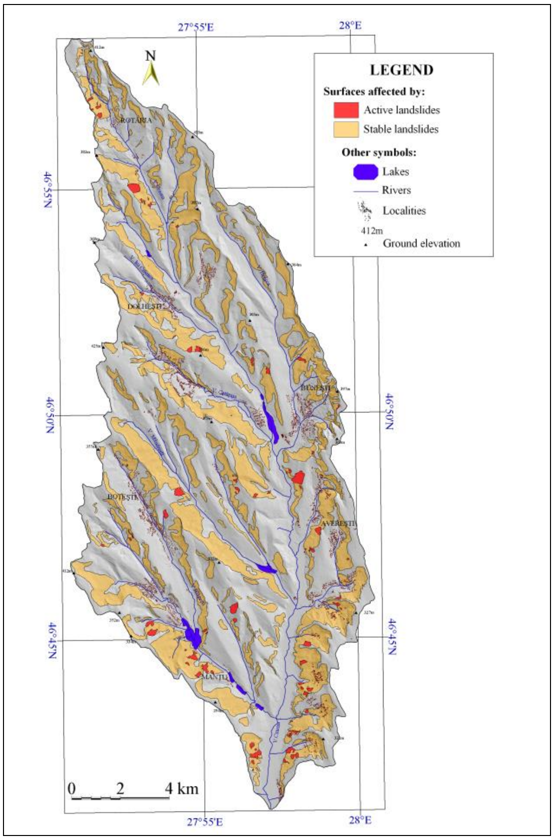


Figure 13: The distribution of landslides in the upper catchment of Crasna

Morphologically, predominate waves-like shape landslides, but it can be found also steps-like landslides (Figure 14 and 15).

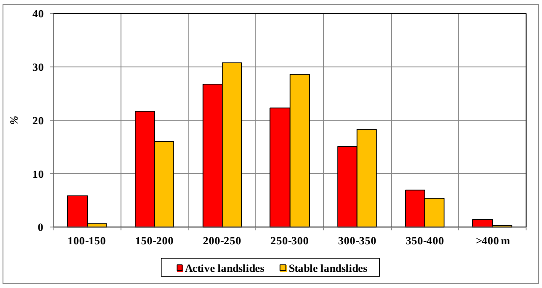
The considerable development and the spread of landslides from the studied area is the result of complex natural and anthropogenic factors. Of natural factors outlined substrate lithology, almost exclusively the Chersonian deltaic facies, the thickness of superficial formations, landscape characteristics (altitude, slope, orientation, etc.), the recording of large amounts of precipitation, the action of surface and groundwater, the density and vegetation type, earthquakes etc.

Figure 14: Waves-like shape landslides in Fundu Covasna Hill (13.09.2012)

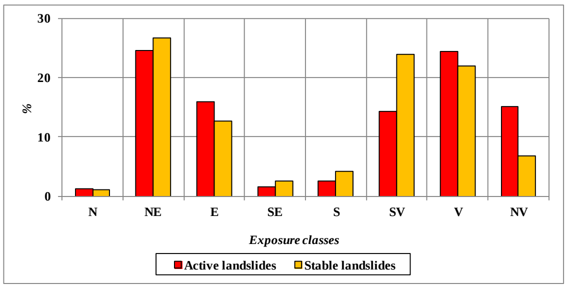
Figure 15: Steps-like and waves-like shape landslides on the left valley-side of Crasna between Giurgeni and Tăbălăieşti (11.09.2012)

The most favourable conditions for the landslide development are found on slopes between 200-250m altitude, north-eastern looking and slopes of over 25% (Figures 16, 17 and 18).

In triggering landslides, a particularly important role it's held by the presence in the substrate of alternating permeable and impermeable rocks. Chersonian-Meotian and Quaternary deposits, found on the surface of the basin are characterized by an alternation of clays and sands, with seems of poorly cemented sandstones, which favours the development of large landslides. Looking at the graph in figure 19, it appears that over 83% of the analysed landslides are developed on Chersonian layers.



Figură 16 Landslides distribution by altitude classes



Figură 17Landslides distribution by exposure classes

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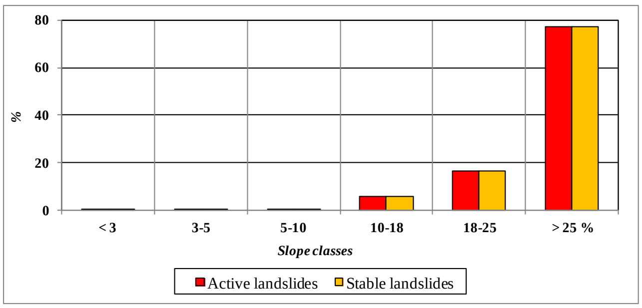

Figură 18 Landslides distribution by slope classes

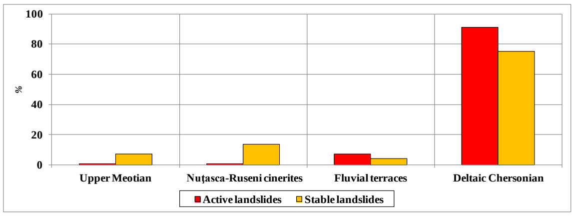

Figure 19: Landslides distribution by geologic formations

Landslides, both the active and the stabilized, mainly affect strongly steep slopes of the cuesta fronts, western and northern looking and some degraded backslopes. Slightly affected by landslides are river terraces, floodplains, poorly degraded backslopes and glacises (Figure 20).

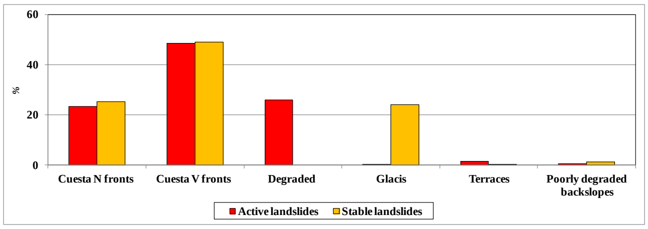

Figure 20: Landslides distribution by landforms

Often, the improper human activity through deforestation, overloading slopes with buildings, making excavations, producing explosions etc. favours conditions for intensification of landslide processes.

3.4. Floodplains sedimentation

The analysis of floodplain sedimentation rate in the upper catchment of Crasna can accurately be done by using the Cesium-137 technique (J. Ritchie et al, 1970, Walling D.E. and Quine T.A., 1992, 1993, as cited by Ionita I. and Mărgineanu R., 2007). For this purpose there were collected sediment samples from a profile located upstream of Bălătău lake, near Podu Oprii village. They were sent for analysis at the Institute of Physics and Nuclear Engineering Măgurele - Bucharest, but they were not completed by the date of publication of this article.Based on field observations it is obvious that the aggradation rate in the upper Crasna floodplain is rather low. This assessment is based on the fact that recent alluvial thickness is reduced, explained by the following reasons: predominantly clayey substratum; predominance of forest soils with fine texture, fairly resistant to erosion; the existence of reservoirs (Podu Oprii / Bălătău, Gugeşti, Manţu, Mândreşti) and significant sedimentation of eroded material at the connection between valley-sides and floodplain.

Conclusions

The present study attempted by a geomorphologic approach to describe the main land degradation processes in the upper catchment of Crasna River. The most representative are soil erosion and landslides, plus subsequent gullying and sedimentation.

Detailed knowledge of land degradation in this specific cut of the Moldavian Central Plateau presents a particular importance to the scientific substantiation of the appropriate soil conservation solutions.

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