LAND USE AND SOIL DEGRADATION IN STUDINET CATCHEMENT (MOLDAVIAN TABLELAND)

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Abstract

Studinet catchment is situated in the eastern part of Romania (Tutova Rolling Hills), having a surface of about 9669 hectares. In this area, the components of both the natural system and of the anthropic one have stimulated accentuated erosion, especially during the last two centuries. The exploitation of GIS techniques and the use of aerial photos allow the diachronic analysis of large land surfaces. Departing from the digital elevation model (DEM) and from the derived thematic maps constructed with the help of the TNT mips software, we have conducted a complex analysis of land use in relationship with the erosion factors (superficial deposits, the length and declivity of slopes, the vegetal cover and its typology). We have proceeded to the analysis of the aerial photos (2005), the database being completed by statistical information and field surveys integrated in the same unitary geographic informational system. We have obtained some indices that would express the actual degradation of the soils a in the present state of land use.

Key words: land use, degradation, GIS

Studineţ catchment is located in eastern part of Romania (Tutova Hills), with an area of about 9669 hectares. In this region, both the components of the natural and of the human system have stimulated strong erosion, especially in the last two centuries (fig. 1).

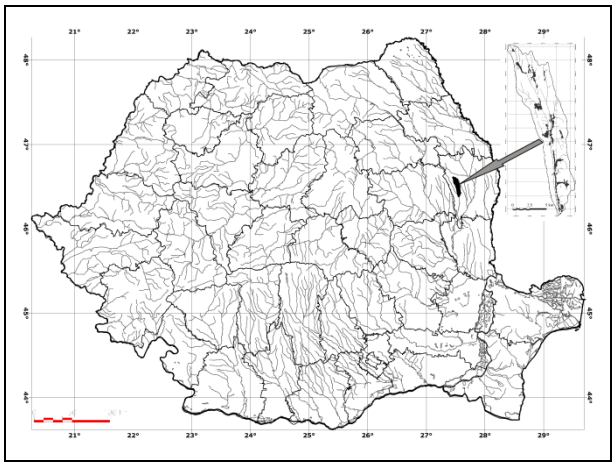

Figure 1 **Location of the research area**

Lithology is represented mainly by sands, sandy clays and, more rarely, clays, in different successions. The general monoclinal structure favors the development of cuesta and hence the appearance of morphological morphodynamic and land use asymmetries.

The predominant sculptural landforms, with a strong fragmentation, condition the dynamic of slope processes by declivity, fragmentation depth etc. From the biopedological point of view, two aspects are important: low weight of lands under forestry and high percentage of eroded soils. Moreover, from the human point of view, Studineţ catchment is a completely rural area with 14 villages and no more than 5000 inhabitants. Unfortunately, this population is in an advanced state of aging and practices a subsistential agriculture, without compliance of any agro technical, economical or ecological principles.

The agriculture of the region is characterized by a deficient land use, atomization of arable plots and farm works frequently realized on down-hill direction. In this context, the excessivety nuances of the temperate continental climate, manifested by a pronounced torrentiality of rainfall, translate into significant losses of soil, especially in the plots of arable land.

MATERIAL AND METHOD

Using GIS techniques and orthorectified photos allows a diachronic analysis on very large surfaces. A complex analysis in relation with erosional factors was made starting from the Digital Elevation Model and the thematic maps, realized with TNTmips software.

Slope length was obtained using SAGA software (System for Automated Geoscientific Analyses), which allows multiple operations with raster files with great applicability in geomorphometry and hydrology.

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The database of aerial photographs (2005) was supplemented with statistical information and field observations integrated in the same geographical information system. Thus, a series of indices could be obtained to express the real degradation of soils in the current land use.

RESULTS AND DISCUSSIONS

The special conditions of the geology, landforms, climate, hydrography, vegetation and especially human intervention led to the deployment on large areas of erosion. Soils are most affected by these processes, large amounts of material that comes mainly from the fertile horizon being transported to the lower slopes.

Sheet erosion develops wherever there is a small slope that could allow runoff through diffuse water flow (laminar ablation). In terms of conditions that favor the installation of sheet erosion, land located on slopes greater than 5% are the most exposed areas (Motoc, 1983).

Regarding the control factors of soil erosion, rainfall is the main agent, especially the heavy rain falls in May-June. In this area, the amount of soil eroded during heavy rains is between 82-98% of the total soil removed by water erosion (Hârjoabă, 1968).

According to Yarnell criterion, applied for the heavy rains recorded at Plopana(north-central part of Tutova Hills) between 1977 and 1994, all the heavy rains were recorded in May-September interval, with the highest frequency in June (37.8%) and July (21.6%).

Rainfall aggressiveness can be asses with suggestive results using $H*i_{15}$ index, H representing the amount of each rain (mm) and i_{15} being the average intensity of the torrential core for 15 minutes (Stănescu P. et al, 1969, Moţoc M., Ioniţă, I., 1983). A good correlation was established (Stângă, 2009) between this index and the amounts of erosion under fallow derived from runoff plot measurements within the Ţarina Valley-Perieni (Ioniţă I., 2000). According to Ioniţă (2000), the maximum risk of erosion under fallow characterizes the months of July, with 12.8 tones per hectare (38.7%), and June, with 10.7 tones per hectare (32.4%). For the corn cultures, the maximum risk corresponds to June, with an erosion of 3.64 tones per hectare (47%) and July with 1.8 tones per hectare (22.8%). Thus, these values define the critical season of sheet erosion, placed between 15-20 May and 15-20 July.

Analyzing the morphometry of the Studineţ catchment, it must be noted that, overall, slopes ranging from 5 to 15 degrees are dominant in the study area (60.11%) (fig. 2).

But even on such slopes slightly inclined (3-5°) but with a predominantly agricultural use (the specific up-down plowing), sheet erosion is active, causing significant damage to agricultural production.

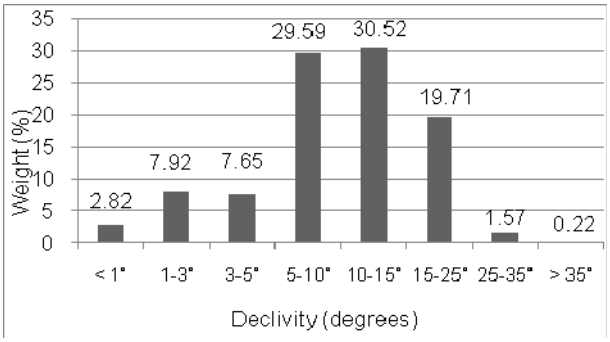

Figure 2 **Weight of slope categories in Studineţ catchment (Iacob, 2011)**

Slope length has an important contribution in sizing of soil losses during heavy rains. In Studineţ catchment, slopes with low and medium length are dominant. Thus, 53.39% of slopes do not exceed 200 meters, 42.11% range between 200 and 600 meters and only 4.51% outweigh the threshold of 600 meters (fig. 3).

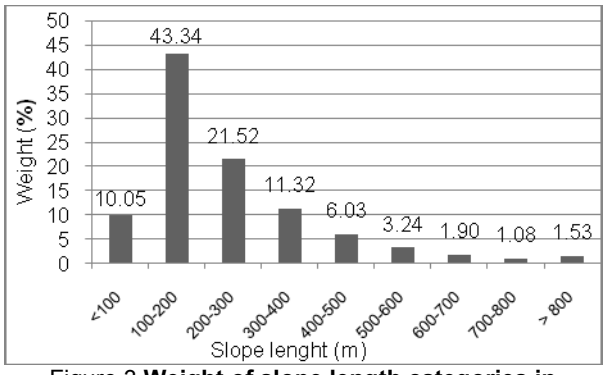

Figure 3 **Weight of slope length categories in Studineţ catchment**

Soil erodibility is another factor with high impact on erosion. Forest soils are the most exposed and occupy important areas in the basin: preluvosols - 23.59%, luvisols - 11.13%, cambic chernozems - 3.55% (fig. 4). The high percentage of regosols (22.27%) and of erodisols (3.95%) shows the extent of erosion.

The most important role in soil erodibility sizing is occupied by the texture, especially the relationship between textural fractions, soils with balanced texture having the minimum erodibility. Organic matter, by helping to create structural aggregates, has an important role in determining soil erodibility, closely linked to infiltration of adsorption capacity. Thus, erodibility visible decrease with increasing organic matter content (Stângă, I.C., 2009).

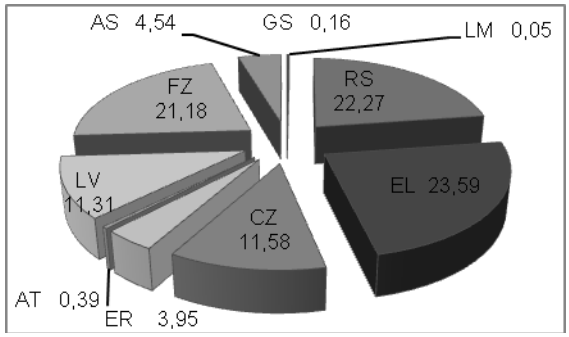

Figure 4 **Weight of soil types in Studineţ catchment (AS - aluviosols, FZ - faeozems, LV - luvisols, AT - anthrosols, ER - erodisols, CZ - chernozems, EL - preluvosols, RS - regosols, GS - gleysols, LM - limnosols)**

For the cambic chernozems, the runoff plot measurements indicate soil losses of 0.88 tones per hectare in an year for wheat, 7.7 tones for maize and 32.5 tones under fallow. The amount of erosion is doubled for the luvisols very eroded and excessively eroded (Ioniţă, I., 2000, 2007).

In Studineţ catchment, land use and land cover are crucial in soil erosion sizing, since the agricultural lands are dominant (55%, that means 5318.25 hectares). The amount of soil losses is different depending on the phenophases and type of annual or perennial plants (Ioniţă I., 2000). The lowest antierosional protection is specific to the corn crops, which occupy more than 70% of the arable lands, and sunflower, 10-15% of arable lands (tab.1).

Table 1

Correction coefficient for crops (Ionită, I., 2000)

Crop	Coefficient
Corn monoculture	1.00
Corn in rotation	0.80
Vine	0.70
Potatoes and beans	0.60
Peas and beans	0.30
Spring strow cereals	0.20
Autum strow cereals	0.14
Perennial herbs in the first year	0.06
Perennial herbs in the second year	0.014

Table 2

Runoff coefficient (Ioniţă, 2000)

Land cover	Runoff coefficient
Arable lands	0.08
Pastures	0.01
Xerotermophilous shrubs	0.005
Vineyards	0.07
Fruit trees	0.005
Lands under forestry	0.001
Courtyards and gardens	0.40
Lakes	0.00
Degraded and unproductive lands	1.00

Runoff coefficients named in table no. 1 and no.2 show the average situation in the study area.

The typical landscape is characterized by a high number of plots

The typical landscape is characterized by a high number of plots (14402), having a very small area, as a result of the Agrarian Law no.18/1991, which allowed the atomization of farms and the misuse on up-down direction (fig. 5, tab. 3).

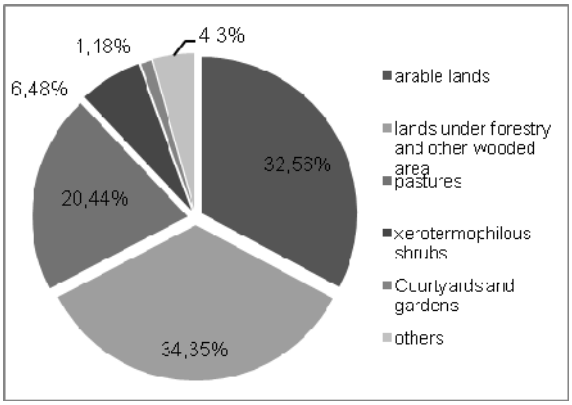

Figure 5 **Land use in Studineţ' catchment**

Table 3

Land use structure in Studineţ catchment

Land cover	Area (ha)	% of total	Total nr. of plots	Avarage area/ plot
Arable lands	3149.48	32.57	12627	0.24
Pastures	2278.05	23.57	1367	2.29
Vineyards and fruit trees	40.96	0.42	408	0.18
Xerotermophil-ous shrubs	324.7	3.36	729	0.44
Lands under forestry	3149.11	34.35	202	15.66
Other wooded Areas	172.52	1.79	103	1.94
Courtyards and gardens	209.59	2.18	35201	0.879
Roads	112.98	1.2	301	0.38
Lakes and Wetlands	7.78	0.08	2	7.77
Degraded and unproductive lands	256.27	2.9	4.16	1.43
Grassy strips	194.08	2	2369	0.82
TOTAL	9669		21356	

Regarding the land use, in the study area, there are a number of 12 627 plots of arable, with medium size of 0.24 ha, occupying an area of 3149.48 ha (32.57% of total). Strong fragmentation of these arable lands, and how working on the hill-valley direction, greatly minimizes the economic profitability and emphasizes the dynamic erosion processes (fig. 6).

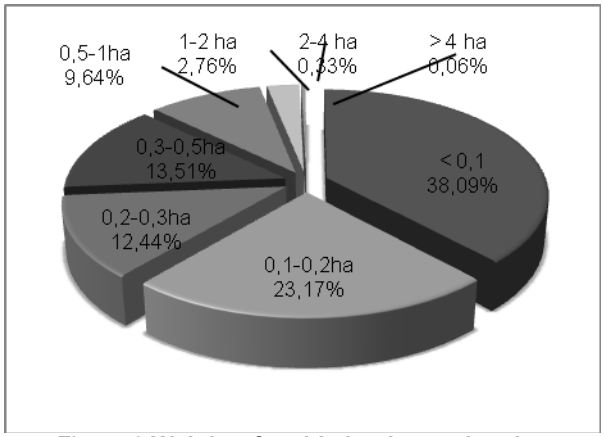

Figure 6 **Weight of arable lands on plot size**

The inconvenience that arises from the predominantly agricultural land use is the very small size of plots with very large length but very small widths (fig.7). Of the total, only 398 parcels exceed 1 ha (3.15%), while the 9306 plots (73.7%) do not exceed even 0.3 ha. The ratio of agricultural area and the total number of inhabitants (5473) points out that every inhabitant is about 6.86 ha of arable land, higher than the European average (imposed by the FAO) of only 0.236 ha/inhabitant.

Figure 7 **Faulty land use in the upper catchment**

Analyzing the distribution of arable land by type of slope (fig.7) reveals the following situation: only 14.35% of the land is occupied by low and very low slopes (3-5°), 39.37% are middle and high slope land sloping land located on the slopes and very strong and very highly inclined have a share of 34.56% of the total arable lands. From this point of view it can be seen that over 73.83% of lands are characterized by moderately and high erosion risk. Without taking into account the arable plots in the villages, with small areas, the average area of parcels in the basin decreases progressively with increasing slope (Stângă, 2009).

Regarding the distribution of arable land on categories of slope length, it is found that the largest share a land is located on the slopes with short and medium length (74.11%), while land located on slopes with large lengths have a weight of only 25.89%.

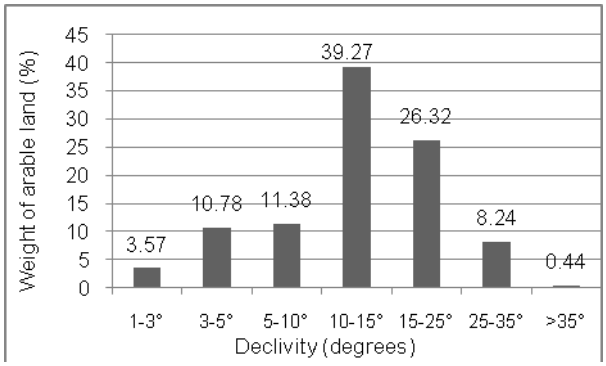

Figure 7 **Weight of arable lands on slope categories**

In Studineţ catchment, only a few areas overlap the normal pattern of anti-erosion works by placing the parcels on contour strips, including grass strips. An example (Fig. 8) is found on the left side of the Silistea basin (cuesta forehead with northern exposition).

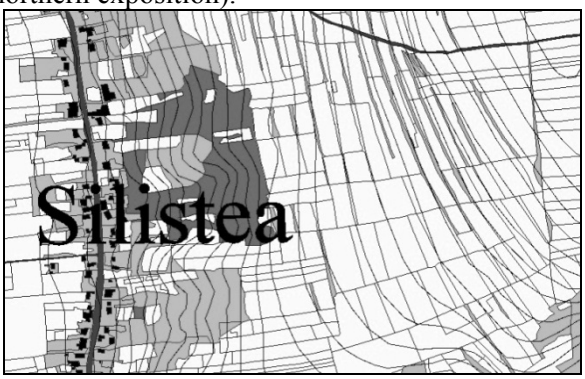

Figure 8 **Anti-erosion works in Silistea catchment**

Grasslands occupy an area of 1368 ha, representing the third category of land use (23 585 hectares, of which 302.15 hectares are occupied by degraded pastures. Stage of degradation of these grasslands is due to their overlap in more than 80% on slopes greater than 10° (Figure 9), and to their improper use by an excessive grazing (within a dry climate).

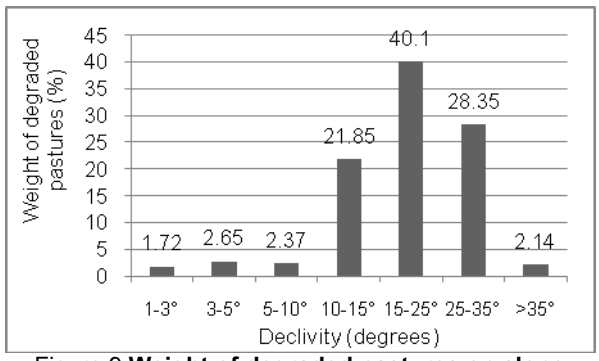

Figure 9 **Weight of degraded pastures on slope categories**

Lands under forestry and other wooded areas occupy important surfaces (3218 hectares, respectively 32.57%), Studineţ catchment being one of the best forested basin in Tutova Hills and

Barlad Tableland. Analyzing the distribution wooded areas on slopes classes (Fig. 10) shows that the largest weight of these are on slopes greater than 15 ° (69.41%), with an important role in stabilizing slopes affected by geomorphological processes. Unfortunately, the degree of compactness of these wooded areas is extremely low and the 202 polygons delineated have areas smaller than 5 hectares (over 81.14%).

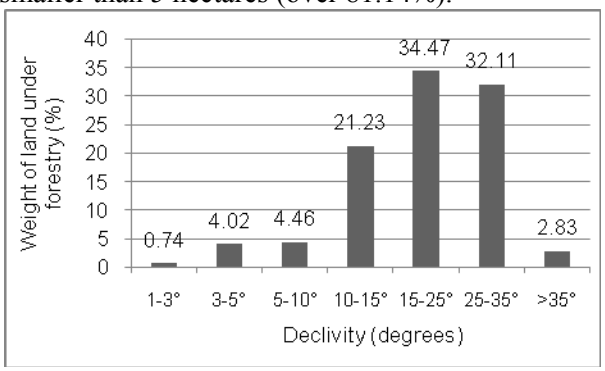

Figure 10 **Weight of lands under forestry and the wooded areas on slopes categories**

Of the total forested area, protection forests occupy only 1.68% and are represented by plantations of *Robinia pseudoacacia*, given its suitability to degraded lands. These plantations are much dispersed, overlapping areas particularly affected by the deep erosion in close proximity to inhabited areas.

Other types of uses (roads, reservoirs lakes, grassed strips etc.) hold a low percentage (4.30%). Of these, access or exploitation roads, defectively positioned on the line of greatest slope (the roads east of the village Gherghești, or the northeast of the village Drăxeni) plays an important role in the emergence deep erosion on slopes, helping water concentration on certain directions and active evolution of gullies (figure 11). Unfortunately, the most part of the gullies and of their drainage basin are not under forestry (figure 12).

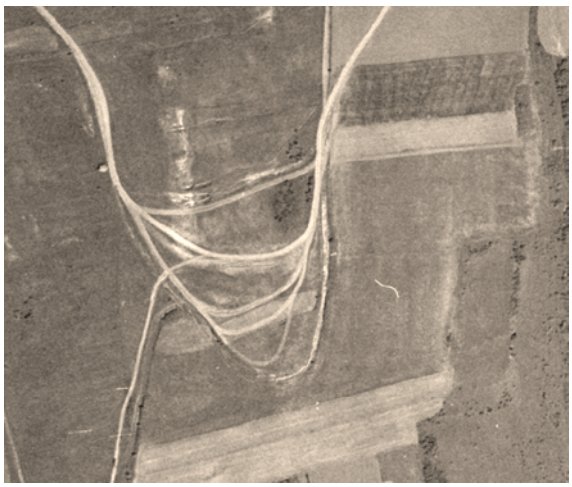

Figure 11 **Roads on slopes east of Gherghesti village**

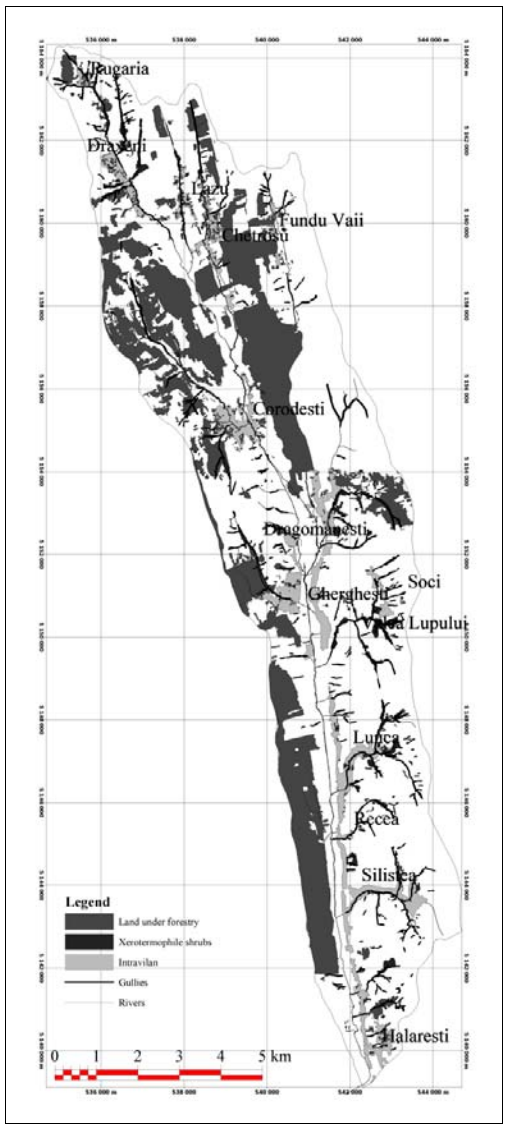

Figure 12 **Forested areas and gullies distribution in Studinet catchment**

CONCLUSIONS

In Studineţ catchment, both the component of the natural system and the human ones stimulated excessive erosion, especially in the last two centuries. Analyzing the control factors of erosion, in correlation with the land use, allow the assessment of the real state of soil degradation in the current context of land cover. Thus, the main characteristic of this area is the existence of a subsistential agriculture system, which amazes by a huge number of small farms and plots and defective land use and works.

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