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LAND DEGRADATION AND SOIL CONSERVATION WITHIN THE SIMILA CATCHMENT –TUTOVA ROLLING HILLS

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Key words: land degradation, soil erosion, gulling, soil conservation

Abstract. The Simila catchment is located in the Tutova Rolling Hills, Southern Moldavian Plateau, and covers 252.83 km^2. The sandy - clayey Miocene-Pliocene layers have been modeled by the local geomorphological factors as a series of parallel prolonged hills which typify the entire area. The improper human activity, mainly deforestation, up and down hill farming and inadequate road network resulted in significant land degradation through the development of sheet erosion, gullying and less through landslides.

The overall estimation shows that sheet erosion produces 12.02 t ha^{-1}yr^{-1} (276500 t yr^{-1}), that represents 56 % of the total erosion within the Simila basin. On the other hand, the value of gully erosion rate is estimated at 7.4 t ha^{-1}yr^{-1} (186075.5 t yr^{-1}). Therefore, total erosion is averaging 19.38 t ha^{-1}yr^{-1} (462,836.9 t yr^{-1}) and proves the advanced state of degradation that characterizes especially the agricultural lands in the research area.

A map of the appropriate conservation practices for the suitable usage of the cropland within the Bogdănița catchment was drafted. The major changes are as follows: the arable reduces to 575 ha, only under strip-cropping system; the quality of the pastures must be improved; the forestland extends from only 232 ha (18% of the entire area) to 507 ha (40%). All unproductive land must disappear.

Introduction

The Simila catchment is located in the Tutova Rolling Hills, Southern Moldavian Plateau, and covers 252.83 km^2.

The sandy - clayey Miocene - Pliocene layers with a gentle gradient of 7 – 8 m km^{-1} NNW - SSE represent the geological substratum (Jeanrenaud, 1966). These deposits are locally covered by Quaternary recent formations.

From a geomorphological point of view, the sculptural landforms typify the entire area and cover over 80.4% of the basin. The accumulative landforms that

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cover 15.8% are followed by the structural and lithological ones with only 3.8% (Niacşu, 2011).

The climate is temperate continental with a mean annual temperature of 9.1^{0}C and mean annual precipitation of about 510 mm. Chernisols and luvisols (forest soils) are among the most common soils and have been used for crop production. The native vegetative cover was dramatically changed over the last two centuries in favor of the agricultural land, mainly cropland (Ioniță, 2000a). The improper human activity, mainly the up and down hill farming and inadequate road network resulted in a significant land degradation especially through the development of soil erosion (Ioniță et al., 2006), gullying (Rădoane et al., 1995; Ioniță, 2000b) and to a lesser extend of landslides (Pujină, 1997).

Starting from this fact, after the 1970s there were many attempts to implement some soil erosion control measures within the area of the Tutova Rolling Hills and therefore in the Simila catchment, which were materialized as land improvement projects (Hurjui et al., 2008; Ioniță and Niacşu, 2010).

Therefore, to improve the quality of the local environment design and implementation of the conservation practices on slopes are necessary.

Two main objectives have been emphasized:

- The overall estimation of land degradation by quantifying the role played by the geomorphological processes;

- The achievement of a land conservation pattern through the identification of the best management practices with main focus on the soil and water conservation.

1.Materials and methods

Firstly, the overall estimation of the land degradation through the main geomorphological processes is achieved for the entire Simila catchment. The soil losses estimation stands on the Moțoc method (Moțoc et al., 1975) that is based on the universal soil loss equation:

$$E=K\,S\,C\,Cs\,L^{m}I^{n},$$

in which: E – average annual erosion (t ha^{-1}), K - the erosivity coefficient based on the rainfall aggressiveness, S - the correction coefficient for the soil erodibility, C - the correction coefficient for the effect of crops, Cs - the correction coefficient for the effect of erosion control works, L – slope length (m), I – slope gradient (%).

The gullying and landsliding estimation is based mainly on field observations and measurements, but also on aerial photos and topographical plans scaled 1:5,000. The obtained values underlie the areas with special degradation problems.

Secondly, considering the present land use pattern within the selected case study area, a map of the conservation practices within Bogdănița catchment is proposed on a helpful scale.

Sizing the width of the strips is done on the admissible average erosion criterion, using the equation developed by Moțoc et al. (1975):

$$L^{0.3} = 6K^{-1}i^{-1.5}S^{-1}C^{-1}Cs^{-1},$$

where: L – width of the strips (m); K - rainfall aggressiveness index; i – slope gradient (%); S - the correction coefficient for soil erodibility; C - the correction coefficient for the structure of crops; Cs - the correction coefficient for the effect of erosion control works.

For a double verification, the strip widths were calculated according to slope declivity (%) and specific erodibility of each type of soil, based on the relationships established by Stănescu (Moțoc et al., 1973): Log L= 2.22 - 0.3i, for erosion resistant soils; Log L= 2.15- 0.3i, for average erosion resistant soils and Log L= 2.05- 0.3i, for less erosion resistant soils, where: L –strip width (m) and i –slope gradient (%).

2.Results and discussions

2.1.*Land degradation within the Simila catchment.* The physical-geographic features of the Simila catchment, enhanced during the last two centuries by an intense anthropic activity, have led to the development of intense geomorphological processes with a role in the generalized land degradation in this area. Among these processes, mainly sheet erosion, gullying and fewer landslides are noticed.

Using the Moțoc method, we have created a map of the average annual soil losses that were caused by sheet erosion throughout the entire basin (Fig. 1). Accordingly, on 63.5% of the catchment's area the average erosion value is under 7 t $ha^{-1}yr^{-1}$, under the admissible value of 6-8 t $ha^{-1}yr^{-1}$, which represents the natural soil regeneration ability. In contrast, the tolerable erosion threshold is exceeded on 36.5% of the area, thus: 7-15 t $ha^{-1}yr^{-1}$ on 11% of the catchment's area, 15-25 t $ha^{-1}yr^{-1}$ on 8.2%, 25-35 t $ha^{-1}yr^{-1}$ on 5.8% and over 35 t $ha^{-1}yr^{-}$1 on 11.6%.

Throughout the entire basin, the specific average value is of 12.02 t $ha^{-1}yr^{-1}$ adding to over 276500 t yr^{-1}. At the level of different landforms, higher values are registered on the cuesta fronts (17.3 t $ha^{-1}yr^{-1}$) and on the highly degraded backslopes (14.8 t $ha^{-1}yr^{-1}$). Among the soil types, high values, above average, characterize the erodosols (28.9 t $ha^{-1}yr^{-1}$), regosols (21.6 t $ha^{-1}yr^{-1}$) and chernozems (14.3 t $ha^{-1}yr^{-1}$), used more intensely as arable lands. The arable lands are the most affected, with an average of 19.1 t $ha^{-1}yr^{-1}$, which represents over 83.6% of the total losses (Tab. 1)

Gullying is the second geomorphological process with a major role in the land degradation within this basin. Using a series of data taken from aerial photos, topographic maps and field elevations, we have identified 1027 gullies, 861 of them being valley-side gullies and 99 valley-bottom gullies (Fig. 2). Also, 67 manmade channels were identified.

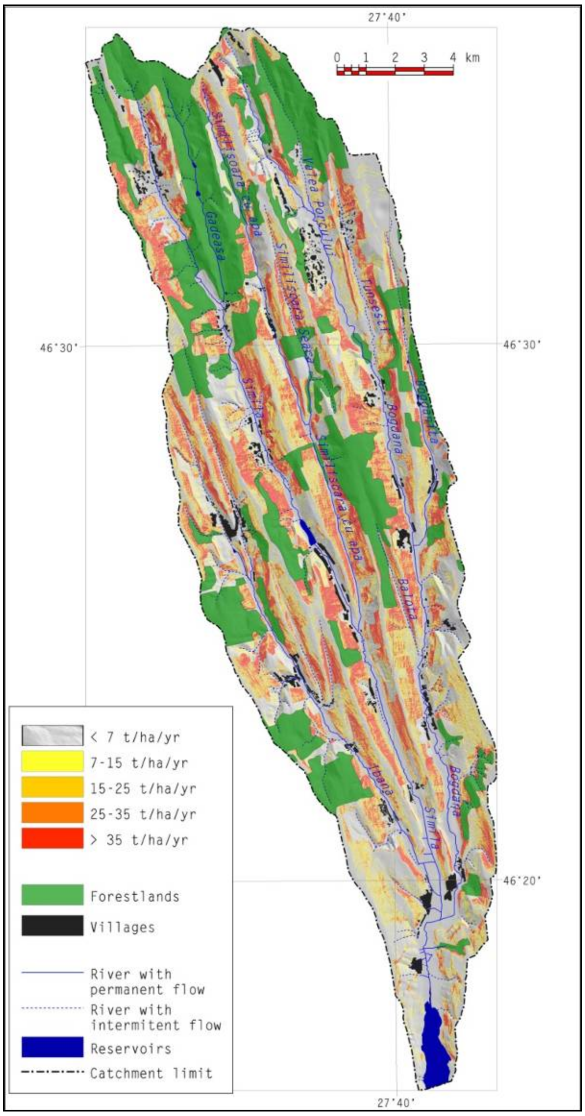

Fig. 1 – Soil losses map (according to the Moțoc method)

Tab. 1 –Soil losses estimation due to sheet erosion within the Simila catchment (according to the Moțoc method)

Land use categories	t yr^{-1}	t $ha^{-1}yr^{-1}$	%
Arable	231052.1	19.07	83.6
Pastures and meadows	11958.5	4.08	4.3
Vineyards	18118.4	19.06	6.6
Orchards	5663.5	35.09	2.0
Forestlands	4127.3	0.63	1.5
Others	5580.4	2.7	2.0
Total	276500.2	12.02	100.0

Relative to the total area of the catchment, the highest proportion is covered by the valley-side gullies (0.28%), followed closely by valley-bottom gullies (Tab. 2). This is due to the fact that valley-side gullies have a smaller average area, of 818m^2, compared to the 6471m^2 average area of the valley-bottom gullies.

Tab. 2 –The gullied area within the Simila catchment

	Gully type	No.	Total area (m²)	Average area (m²)	Proportion of total gully area (%)	Proportion of total basin area (%)
1.	Valley-side gullies	861	704258.3	818.0	44.9	0.28
2.	Valley-bottom gullies	99	640724.9	6471.9	40.9	0.25
3.	Manmade channels	67	222223.6	3316.7	14.2	0.09
	Total	1027	1567206.8	1526.0	100	0.62

Usually, the highest gully density is found in the middle and lower sectors on mostly sandy lithology. However, the decisive factor in the initiation and development of gullies in the Simila catchment is the anthropic one, especially through the inappropriate land use.

Starting from the 960 inventoried gullies, 15 valley-bottom gullies were selected as representative and a series of gullying specific indicators were calculated based on them.

Results show that the increase in length of the selected gullies was 75.2 m, with an average of 2.7 m yr^{-1} and an average annual gullied area of 26.9 m^2yr^{-1}. The average annual volume eroded by gullying has a value of 490.8 m^3yr^{-1} and the average annual quantity of solid material is 788 t yr^{-1}. The equations proposed by

Ioniță (2000b) were used for these two parameters, starting from the increase in length of the gullies. Therefore, generalizing for the entire basin, the average annual losses caused by gulling reach 186075.5 t, representing over 7.4 t $ha^{-1}yr^{-1}$.

Fig. 2 – Gullies distribution map within the Simila catchment

Landslides are not very important, affecting only 8% of the total area of the basin. The ones causing most problems are the active landslides and the partially stable ones, which occupy only 0.4% of the basin's area. The stable landslides are old, dominating the upper basin and which probably appeared in other climatic conditions than the current. Besides, currently, within the Simila catchment, the main cause of landslides is gullying.

Starting from the results obtained by Pujină (1997), within the catchment an annual quantity of almost 261.2t (0.01 t $ha^{-1}yr^{-1}$) is lost as a result of this geomorphological process.

Adding up, there is a total quantity of eroded material of about 462,836.9 t yr^{-1} within the Simila catchment, with a specific average value of 19.38 t $ha^{-1}yr^{-1}$. Relative to arable lands, the 28.64 t $ha^{-1}yr^{-}1$ prove the advanced state of degradation through erosion that is typical to the lands of the studied area.

Closely connected to the erosion processes, the sedimentation cause problems through the aggradation of valley-bottoms and silting. The average rate of sedimentation in the Simila catchment has a value of 3.3 cm yr^{-1}, calculated during the 1963-1986 period and about 1 cm yr^{-1} during the 1986-2006 period (Niacşu, 2011). The average sedimentation rhythm in the Tutova Rolling Hills accumulations has an average value of 7.5cm yr^{-1} (Ioniță and Mărgineanu, 2006).

2.2. ***Sustainable land use pattern within the Bogdănița catchment.*** The Bogdănița catchment, located east of the Simila catchment, has an area of 1269.7 ha. Its typically consequent valley, with a NNW-SSE general flow direction, is a representative valley for the entire Tutova Rolling Hills area through its characteristic geomorphological features. This is the reason why the area was selected as a case study for drafting an anti-erosion land improvement model with a role in preserving and possibly improving the quality of land in the research area.

2.2.1. Present land use pattern. According to the current land use map, within the Bogdănița catchment, of the entire area about 50% is used as arable (47.87%), 607.8 ha, respectively (Fig. 3). Actual arable land represents 597.9 ha of this area and 9.9 ha are represented by vegetable gardens. The actual arable land covers the right slope, eastern exposition backslope and also the superior third of the basin, where a structural-lithological plateau with low declivity is contoured, favorable to agriculture.

Vineyards appear mostly near the Bogdănița and Schitu villages and cover an area of 21.2 ha, 1.6% of the basin's area. The varieties grown are both hybrid (10.1 ha) and noble (11.1 ha). Orchards appear on the left slope, cuesta front, which is not favorable to use as arable, along the Bogdănița village and downstream of the Schitu village. Currently, the whole area covered by orchards (17.7 ha, 1.4% of the total area) is abandoned.

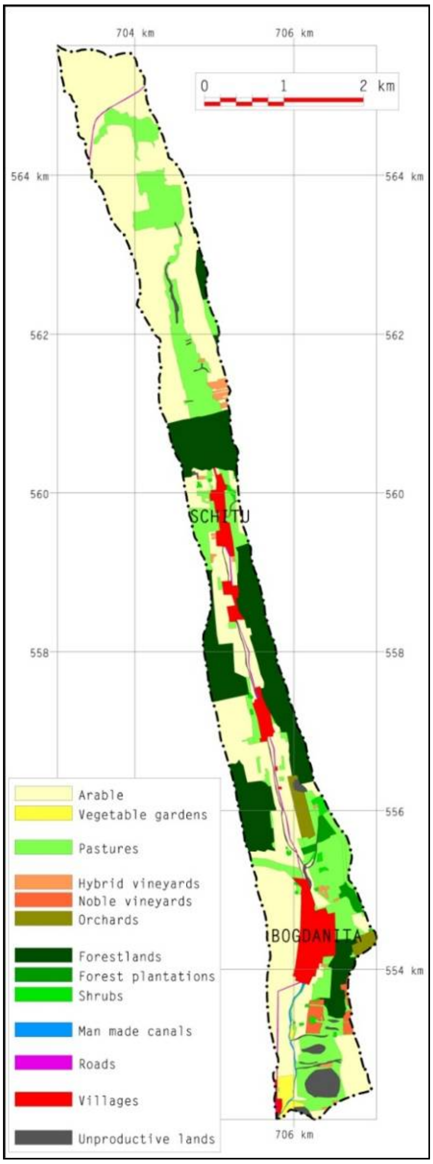

Fig. 3 – Current land use map within the Bogdănița catchment

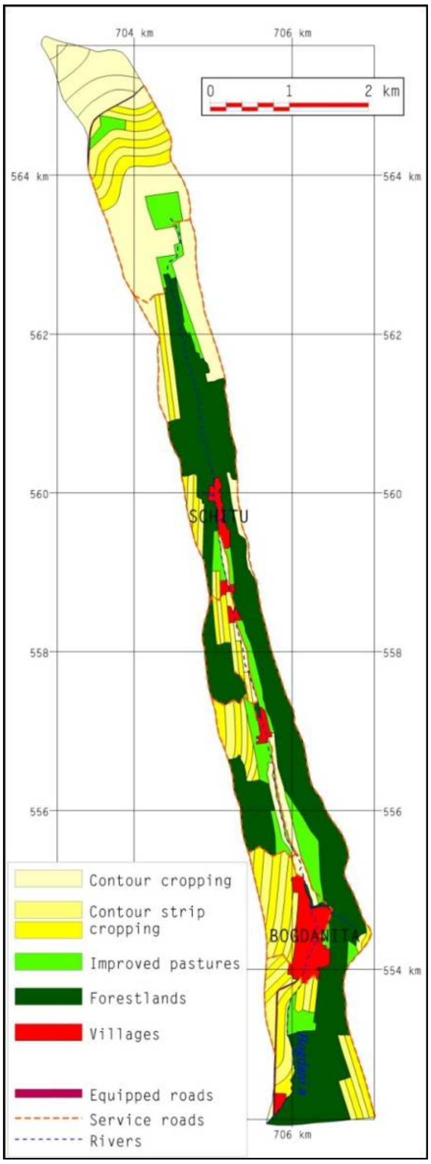

Fig. 4 – Map of the conservation practice within the Bogdănița catchment

A significant area is covered by pastures (255.1 ha, 20.1%) mostly on the highly degraded lands. Forestlands dominate the middle third of the basin, on the slopes with higher declivity affected by intense geomorphological processes. Smaller forestland areas occur also in the inferior basin near the Bogdănița village.

Of the total area of the catchment, only 232.6 ha (18.31%) are covered by forests. Near the Bogdănița village, on the cuesta front left slope, between the forestlands tree screens, shrubs and briers grow.

The built-up area in the Bogdănița catchment is represented by two villages, Bogdănița and Schitu, which take 5.83% of the area.

The intense land degradation within the Bogdănița catchment, especially on the left slope, has led to the appearance of unproductive land on about 31.3 ha.

2.2.2. Soil conservation pattern within the Bogdănița catchment. Starting from the current land use pattern, using topographic maps (1:5,000 scale), aerial photos from the year 2005 and field data, a soil conservation plan was drafted, with the purpose of reducing annual soil losses on the slopes and increasing agricultural production (Fig. 4).

By analyzing the resulting map, the main conclusions are:
The lands degraded through gully erosion and mass movements must be covered by forestlands. Where afforestation doesn't ensure good bank stabilization, slope stabilization works are required, or stabilizing with gabions placed longitudinally in critical spots (Hurjui et. al., 2008).

Forestlands must keep their purpose, and their area must increase to 507.78 ha (40% of the entire area of the basin) at the expense of areas with unproductive land, shrubberies or degraded pastures (Tab. 3).

Tab. 3 –Share of the proposed land use categories (scale 1: 5.000)

	Land use categories	Area (ha)	Area (%)
1.	Arable	575.22	45.3
1.1.	*Contour cropping*	*254.94*	
1.2.	*Contour strip cropping*	*320.28*	
2.	Improved pastures	118.38	9.32
3.	Forest plantations	507.78	40
4.	Villages	64.1	5.05
5.	Roads	4.19	0.33
Total		1269.67	100

Pastures reduce their covered area to 118.38 ha and appear at the base of the backslope and on smaller areas in the north of the basin.

The biggest problems regarding the anti-erosion land improvement occur in the case of agricultural lands, their use having to be restructured according to slope declivity. For the study area, the most adequate anti-erosion systems for arable lands are:

a.Executing only *contour cropping* on the low declivity lands of the structural-lithological plateaus, interfluvial hilltops and at the base of the slopes, on glacises. Of the entire 1269.67 ha area, 254.94 ha have a declivity value lower than 5%, which recommends them for agricultural use.

b.Introducing the anti-erosion system of *contour strip cropping* on lands with declivity between 5% and 12%. The contour strip cropping system is suitable for use on the right slope on approximately 320.28 ha.

Havreliuc (1977) reached the conclusion that the optimal strip length is about 2000-2200 m. Therefore, in this case, a strip width between 59 m and 150 m resulted, depending on slope declivity and soil type. However, the best recommendation would be the combination between the strip-cropping system and a network of wind-breaks, each of them 12m in width.

c.Adopting the anti-erosion system of *grassy strips* on the slopes with declivity between 10% and 18%. The width of these strips should be 4 m, and the distance between them is calculated with the same formulae used to calculate the strip width for the previous system.

d.The *terrace* system on arable land is very expensive and therefore the circumstances show that the most efficient solution is represented by the combination of strip cropping with grassy strip system. Where old terraces still exist, such as those on the right slope, alongside the Bogdănița and Schitu villages, they must be maintained.

After establishing the land use pattern and the anti-erosion systems on arable lands, the serpentine primary and secondary (on the contour) operating roads have been traced. The existing roads on the interfluvial hilltops must be maintained and transformed into primary roads and the road at the base of the slopes must be kept.

Conclusions

According to the accomplished project, within the Bogdănița catchment, the arable area should be reduced to about 575 ha, only on the lands with a declivity lower than 18%. Special attention must be paid to the improvement of pastures which must cover about 118 ha, by significantly extending the area covered by improved pastures. It is recommended to extend forestlands from just 232 ha currently (18% of the total area) to over 507 ha (40%), mainly on the slopes intensely affected by land degradation processes.

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