LAND USE, MORPHOMETRIC CONDITIONS AND LAND DEGRADATION THROUGH EROSION IN SOUTHERN TRANSYLVANIA. CASE STUDY: CÂLNIC RIVER BASIN

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ABSTRACT
The current geomorphologic processes are a form of land degradation. This is accomplished by mechanical removal of the alteration layer and soil layer as a result of the action of rainfall (splash erosion, rill erosion), of concentrated flow and of gravitational processes. These are conditioned by natural factors like: type of rock, geological structure, relief morphometry and modeling agent. However, the natural processes action is enhanced and complemented by anthropic intervention in the riverbeds and interfluvial surfaces and slopes, through the specific activities of forest and agricultural use. To assess the role of land use in shaping of slopes and land susceptibility to erosion we related the distribution of erosion forms on the Câlnic basin with different types of land use (arable land, vineyards, grassland, wood and built – up area). The potential of degradation through erosion was investigated in this basin, analyzing the morphometric indicators which facilitated the erosion process (elevation, slope, aspect and curvature of surface) and the land use.

Key words: land use, morphometry, erosion, land degradation, Câlnic basin, Transylvanian Depression

INTRODUCTION

The concept of "land degradation" is very complex and may be approached by several areas of research: geomorphologic, pedologic or/and agronomic degradation. Current geomorphologic processes are among the causes of land degradation and of qualitative and quantitative soil loss. These may be considered as risk phenomena given that they cause economic loss, land use change, removal of large areas of land from the agricultural use. In Europe and worldwide, efforts are made to record, monitor and mitigate environmental risks, especially those related to erosion, resulting in a series of research programs. The issue of slope erosion has been addressed recently internationally (RENARD et al, 1996; BONARI, DEBOLINI, 2010; KNIJFF, 2000) and in Romania (MOTOC et al. 1975, MOTOC, MIRCEA, 2005 etc.). The ICPA has conducted national surveys of this type.

MATERIAL AND METHOD

The surveyed area is part of the sub-mountainous depression located at the contact of the Southern Carpathians with the Transylvanian Depression. Since the submountainous depression area situated to the north of Cindrel Mountains is very large (over 70 km length) and analysis at this scale would be subjective, we proposed a detailed analysis on a representative basin of this contact area. The analysis covers a small area (31.5 km^2), but its features are found in other river basins of sub-mountainous depressions.

Câlnic River is a left tributary of the Secaşul Mare River in the Apold Depression, downstream to Miercurea Sibiului, and its source area is on the Gârbovei Hills. The geological features are reflected in the pattern of relief and in morphometry. Steps relief lower in altitude from south to north: submountain hills, glacis, terraces and common meadow of Secaşul Mare and Câlnic River. Moreover, submountainous hills, glacises and terrace fronts have a high potential for degradation imposed on geology. Badenian, Sarmatian and Pannonian deposits consisting of sandstone, gravel, marls, clays and sands and the lack of vegetation provides extremely high morphodynamic potential to the slopes. Above these substrata there are quaternary deposits (gravels, sands, loamy deposits etc.). In these circumstances, the aggressiveness of precipitation and flow associated with human activities and land use are active factors of land degradation.

The meteorological-climatic conditions influence the modeling of the relief through the prolonged regime of precipitations in spring – summer period. In July it reaches the maximum multiannual monthly value of precipitations (70.4 mm in Sebeş) and then falls until February to the minimum value (19.7 mm in Sebeş). Significant for the modeling intensity are: the alternation the periods characterized by increasing precipitation with those of intense drought from the autumn months especially in the depression area. (COSTEA, 2005). Under these circumstances the declivity and the insulation of grassy or vegetationless slopes with favourable exposure cause the forming of deep cracks in the hill area, these being later overtaken by precipitations or snow melting water.

Methodology

Our study is based on GIS techniques. In order to achieve the DEM has been used ArcGIS 9.2. software packages. The topographic base used was the map of Military Topographic Institute of Bucharest, edition 1982, scale 1: 25 000. It was updated on the based on orthophotoplans and on field observations. Based on digital terrain model were determined morphometric indicators: hypsometry, declivity, aspects, curvature respect horizontal and vertical planes (COSTEA *et.al.*, 2011). These indicators are most often used in geomorphology to indicate potential slope imbalances generated by surface and concentrated flow. The relation between surface morphology and potential of degrading through erosion and land use was determined descriptively and statistically by means of the distribution of erosion forms and processes according to individual types of land use, classes of altitude, slope, and aspect of the surface. Using GIS techniques, based on topographical maps, the orthophotomaps and our own observations on site the distribution map of erosion forms (rill, ravine, gully) and the land use map were developed.

RESULTS AND DISCUSSIONS

Land Use and its Role in Morphodynamic

The sub-mountainous area is suitable for habitation and agriculture, which generated a high anthropic pressure. This was possible due to the favorable relief and climate conditions, the rich water network, the high accessibility. The Câlnic basin is developed between 260 – 723 m altitude (*Fig.* 1). The depression sector occupies more than 75% of the entire basin. Development in altitude of the basin (over 400 m) is reflected in the distribution of settlements and in the use of land. There are two rural settlements (2% of basin surfaces): Câlnic, situated in the alluvial plane between 325 – 350 m altitude and Deal, a hill settlement situated on the north versant of Zapodia Hill between 525 and 595 m altitude. This is also the altitudinal limit of permanent settlements in the analyzed basin. Under 400 m altitude, are developed the alluvial plain and the terraces of the Secaşul Mare river and the terrace glacises, with a predominantly agricultural use. The Gârbova Hills are in the south, where the predominant use is growing, pastoral and forestry.

The cultivable land occupies 30% of the total basin area, pastures and grasslands 37%, the vineyard and orchard 19 % and the forests 12 % (*Fig*. 2). Forestry spontaneous vegetation on the hills in the south part of Câlnic basin or natural hayfields on the slopes in inferior basin have undergone significant changes through deforestation and reclamation (CIORTEA, 2005). The major changes were made during the previous centuries when important forest areas were replaced by grassland and arable land. Nowadays, the most important changes in land use have been introduced by legislation through restitution of land in private propriety (Laws 18/1991; 169/1997; 1/2000, 247/2005). The exercise of ownership rights and the limited financial possibilities of a predominantly rural and aging population have led to land fragmentation and often inappropriate administration. The mosaic character of land-use categories, the different types of land use and agricultural practices are, for the entire basin area, active factors in triggering slope processes. A negative impact to the slope dynamic equilibrium it has dividing land into small lots, the creating of roads and paths access to them, and abandoned farmland or engaging in farming techniques incompatible with the soil, geologic underground or slopes typology.

Relief Morphometry as Favorable or Restrictive Conditions

In the Apold Depression, where is situated the analyzed basin, these processes developed on autochthonous basins of inferior order (Câlnicul, Gârbova, Reciul, Dobârca, Apoldul) contribute to the fragmentation of the Secaşul Mare river terraces and the degradation of piedmont glacis at the foot of the Cindrel Mountains (COSTEA, 2005). The slope processes generated by pluvial denudation dominate: superficial erosion due to raindrop and rainsplash erosion, rill erosion, gullying, torrential erosion. The processes of erosion, transport and accumulation also take place along the Câlnic valleys. The analysis of the morphometric particularities provides us valuable data on the evaluation of the erosion processes through the outline of dispersion or drainage concentration areas and those of predominant erosion or deposition. In order to highlight these aspects, we have resorted to GIS applications and to indices of the plan form curvature and profile curvature.

Basin ***hypsometry*** shows an uneven distribution of altitude steps. The steps between 300 and 400 m and 400 and 500 m occupy the largest areas (over 80% of the basin). The share of other hypsometric levels is reduced, the smallest area being occupied by the altitudinal step over 700 m (*Fig.* 1). This distribution reflects on land use, by the predominance of crops at about 300-400 m on slightly inclined surfaces of glacises, and flat areas of the terraces of the Secaşul Mare river. The high humidity of the plains Secaşul Mare and Câlnic River plains Great restrict land use to hayfields. Forest areas occupy upper slopes and ridges, concentrated mostly in the altitude range 400-500 m. Forest development is maximum, on the Reciu - Dâlma ridge. On the interfluve to the left of Câlnic river, the forest is not very developed. Sporadically, disseminate between 350 and 450 m of altitude there are vineyards and plum orchards. In the southern part of the basin, they extend across the hypsometric step of 500-600 m near the rural settlement Deal. Their extension is facilitated by the low inclination of the interfluve between the Câlnic and Valea Lungă rivers, and the climate with frequent influences of the Föehn. The base of the slopes, i.e. the lower half is used as pasture. Grasslands widespread on the hypsometric range of 400 to 600 m and up to 650 m in the source area of the Câlnic River and its tributary Valea Lungă river. In terms of land degradation, the highest concentration of the forms of erosion is in the pasture area. Forms have dimensions of length and depth indicating increased erosion. The erosion distribution map indicates a high density of drainage channels, ravines and gullies in this altitudinal range.

The ***slope*** is a morphometric indicator which influences the intensity and frequency of the erosion degradation processes (*Fig.* 3). Moreover, the slope is involved in land use, the angle size favoring or restricting certain types of use.

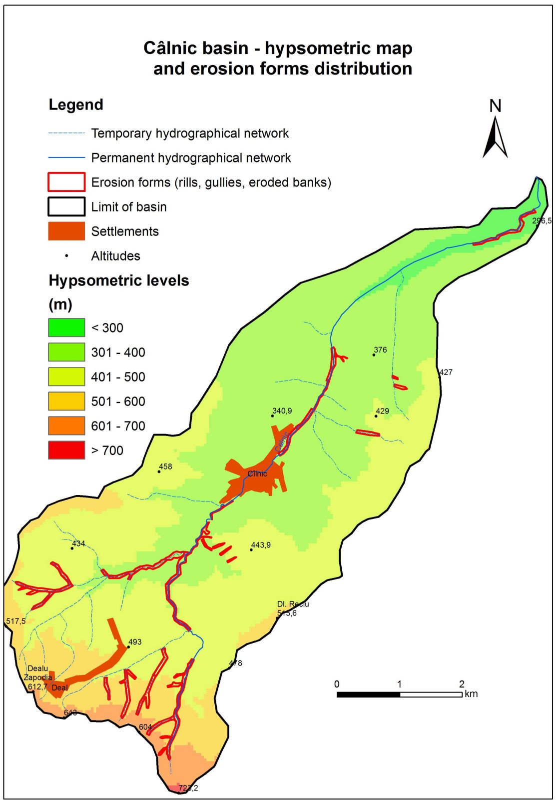

Figure 1. Hipsometric map

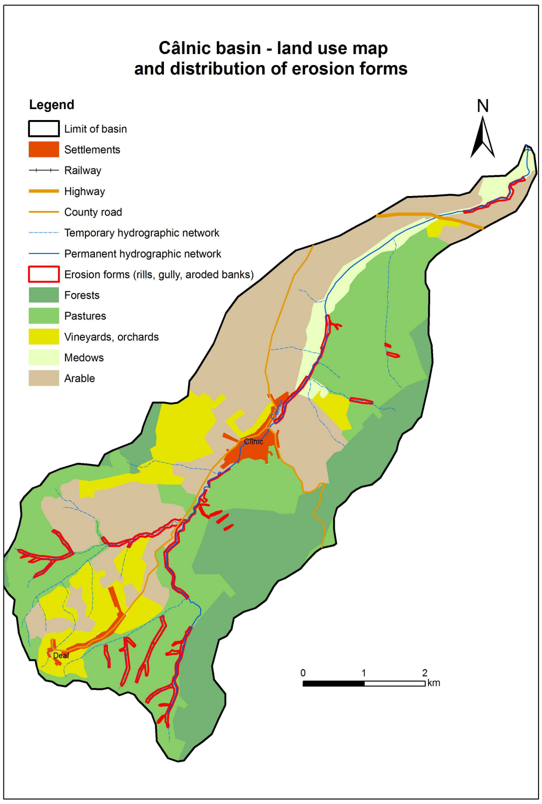

Figure 2. Land use map

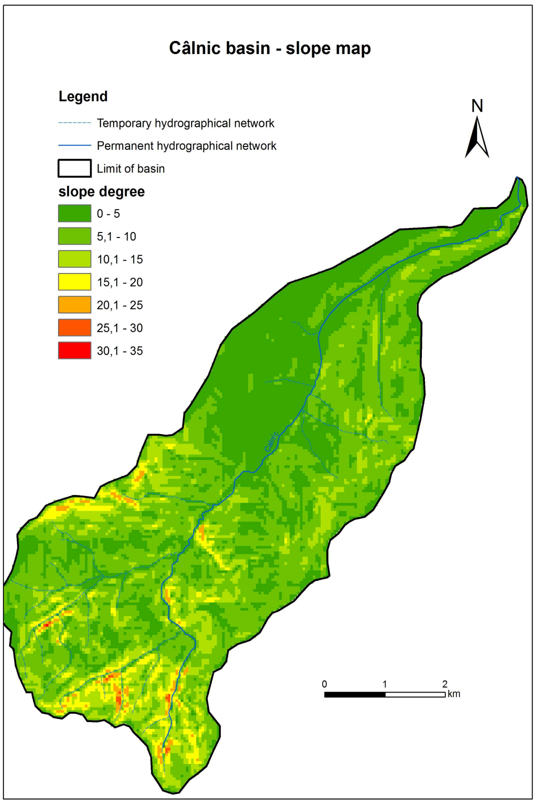

Figure 3. Slope map

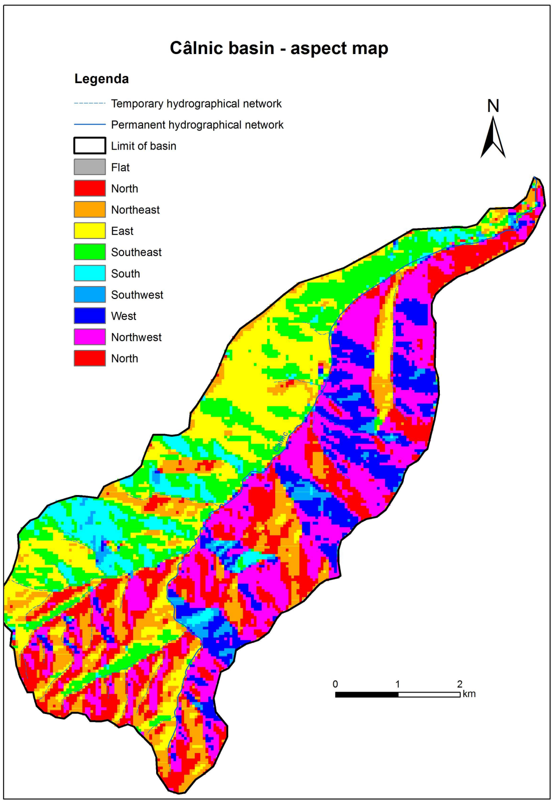

Figure 4. Aspect map

In the Câlnic River basin, the slopes slightly exceed 30°, the maximum slope being 31.4°. The most frequent are the slopes ranging between 0 and 5° (35.2%) and 5 - 10° (45.6%). They are found in meadows, on the Secaşul Mare River terraces, on the terrace glacises, used as arable land or grassland, and on top of interfluves, area which is used as pasture or forest. Medium slopes ranging between 10 and 15°, occupy 14.2% of the area and are found on the versants in the lower half and on the contact glacis. These slopes are favorable to fruit growing and viticulture. Vineyards and orchards occupy the versants with slopes below 10° (2 - 10°) and are fragmented by a network of temporary valleys.
Steep slopes occupy smaller areas: 4% between 15 to 20° and 1% over 25°. They are located on the versants of the foothills - the Zapodia Hill strongly fragmented by gullies, ravines, ravine streams which form the source basin of the Câlnic river. The highest density of the forms of linear erosion is found on slopes exceeding 15°. The change in land use has led to accelerated erosion and land degradation. The phenomenon is also indicated by the toponym "Între Pâraie", (in English, "Between Streams") which shows a high density of forms of linear erosion. Steep slopes are encountered on the left side of the Câlnic river at the top of the versant in the Sfânta Forest. Forest use in these sectors, however, is a factor of stability of versants. The forest water consumption impacts upon the flow control, reducing the amount of water drained from surface and the erosion intensity.
Versant exposure is clearly influenced by the SW-NE orientation and the mostly northern exposure of the Câlnic River basin and the high fragmentation, especially in the upper basin (*Fig*. 4). Predominant are shaded and partially shaded versants (66.85% of the basin area). The most frequent are the versants with a north-western exposure (19.4%), followed by those with an eastern (17.35%), northern (16.2%), north-eastern (13.3%), Western (10.63%) exposure. Of the versants with favorable exposure, the most numerous are those with a south-eastern (14.4%), eastern (10.63%) and southern (5.95%) exposure. South-western versants and flat areas occupy each about 2%. Despite the lower proportion of sunny and partly sunny areas, the versants are mostly used for crops, viticulture and horticulture. This usage is mainly due to the low inclination, which facilitates the reception of a higher quantity of sunlight, irrespective of exposure. Viticulture is present on versants with different exposure (E, SE, NW, W, S, SW), precisely because of the favorable slope, but it prevails on sunny and partly sunny versants. Forest use does not depend on versant exposure. Thus, forests are spread on top of the interfluves.
With respect to the relation between slopes and land degradation through erosion, semi-shaded and shaded versants are the most affected by this phenomenon. This is explained by the higher moisture in the soil and the substrate on these versants, by the higher stability of soil aggregates and the higher infiltration capacity on the versants with a warmer microclimate (SANCHIS *et al.* 2008).

CONCLUSIONS

Following the analysis previously made we can synthesize the conclusions. Land use depends on the altitude, except for vineyards and orchards. Arable land decreases with altitude, and grassland and forested areas increase with the altitude. Forests are extended on ridges and upper versants and are compact. The increase of slopes determines the decreases of the arable land area, and the wider the area occupied by pastures and hayfields. The last are located on versants with moderate to high slopes, which facilitate degradation through erosion under the circumstances of the pastoral use and rainfall surplus.
Versant exposure influences land use less than inclination. Even in the case of vineyards which require favorable exposure, this condition is not met. Vineyards and orchards are

scattered across the area, on low and moderate slopes with different exposures, but are still prevalent on sunny and semi-sunny slopes. The connection between land use and erosion risk is weaker in the lower basin and stronger in the upper basin. The mostly degraded areas are in the south of the basin in the Gârbova Hills, at an altitude between 450 and 600 m, where in the late eighteenth century forests were cleared in order to extend the grazing area. There is also a strong connection between altitude and slopes and the erosion risk. The forms of erosion are more common in higher elevations, on moderate slopes and steep slopes and shaded and semi-shaded versants.

The impact of geomorphologic processes on land is becoming more pronounced, resulting in a series of disturbances on the versants and damage in agriculture and forestry. Under such circumstances, an integrated approach to land degradation, a good inter-institutional collaboration and responsible involvement of specialized agencies are required. All development plans regardless of scale (local, regional, inter-county etc.) must observe the principles of sustainable development and be based on assessment and monitoring to reduce the impact of land degradation on the environment, the economy and the society.

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