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RESEARCH CONCERNING GULLY EROSION EVOLUTION ON AGRICULTURAL LANDS

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Abstract

Gully erosion initiation and evolution on agricultural torrential watersheds, as well as the prevention and their control works, represent a very complex process. Despite the fact that most of the gullies in such hilly areas have been partly or even totally stabilized in the past, today some of them continue reactivating in time, mainly on the gully bed due to several factors, among them being the poor maintenance of the anti-erosion works. The paper aims to present and analyze some practical aspects concerning gully erosion today's evolution from one of the most affected area in Romania by soil erosion and landslides, the Subcarpathians Curvature. The research of the case study was carried out in the spring of the year 2014 in comparison with the reference year 1997in terms of gully evolution on Tatarului Valley.

Key words*: land degradation processes, gully erosion, sediments, check dam*

INTRODUCTION

Soil erosion, in general, and gully erosion process, in special, affects an important part of the Romanian territory, both agricultural lands and forests. Apart the surface erosion and landslides, gully erosion affects an important part of the Romanian agricultural lands and forests. The most significant types of gullies in the country are the torrents and ephemeral as well as permanent gullies that are present in several locations. Continuously gully erosion development produces important damages to the agricultural lands, human settlements and socio-economic units. Slanic's hydrographic basin is located in Buzau county, in the country's southeast. Buzau County has an area of over 600,000 ha which have a distribution of 19% mountains from the area, hills and plateaus 31% and a vast plain that represents 50% of the Buzau County. Slanic River watershed is a tributary to the Buzau River on his left side and their confluence occurs in Sapoca village. Slanic watershed has an area of over 54,000 ha and a length represented by 65 km found mostly in the Subcarpathians Curvature. Slanic River represents the Eastern boundary of Muntenia's Central Sub-Carpathians and separates Vrancea Mountains from Buzau's Plain. Buzau area represents an interest to our field of activity and continuously research because there are recorded the most significant soil losses in the country. In Buzau County it has been inventaried a gully erosion network of about 1,000 km, that represents about 1,000 hectares of agricultural lands (Mircea, 2000, 2008). Having in view the complexity of the land degradation processes in the Slanic Valley watershed, a huge interest is represented by several of the sub-watersheds, being mainly located in the low and medium third parts of the watershed, which were taken into study in this paper. In our study we have made a topographical survey on the gully from the Tatarului Valley, which is located on the right side of Slanic River (Figures 1 and 2).

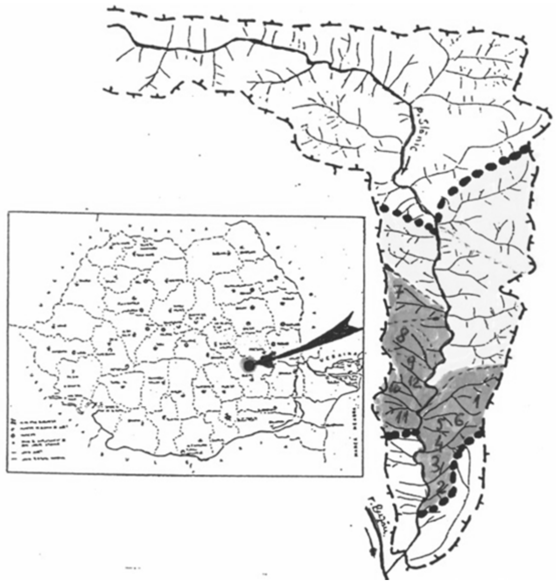

Figure 1 Sketch of the studied area, Slanic/Buzau, Sub-Carpathians Curvature region, Buzau County, Romania

Figure 2 Topographical survey on the gully from the Tatarului Valley, Sub-Carpathians Curvature region

MATERIAL AND METHODS

The field measurements on the studied gully were carried out in the spring of year 2014, in a location situated next to the Soil Erosion and Conservation Aldeni Research Station - Buzau (Subcarpanthians Curvature zone), an area characterized with loamy textured chernozems and mean annually precipitation of about 450 mm, out of which about 350 mm are fallen during the vegetation period, April-September. All these natural features illustrate the influence of slope and land use on soil loss, especially on gullies, being in this way identified the best soil conservation measures.

The most significant gullies in the country are the torrents and permanent gullies, which are present in several locations. As it is known, gullies development on the three main directions - in length, width and depth, has a major impact on environment, either on short or long term. The continuously development of the gullies causes important damages to the environment, in general, to the agricultural lands in special, as well as to the human settlements, watercourses and various socio-economic units, such as reservoirs or hydropower plants, transportation ways etc. According to M. Motoc (1999), gully erosion only contributes by 31% to the total soil erosion in Romania, generating about 36 million tons/year of alluvia. Annual losses of agricultural lands have been estimated to around 2,300 ha. Gullies' evolution in length has become in time more and more important. To better predict the rate of gully headcut advance, so far there have been developed several specific determinist models, out of which can be mentioned: Thompson (1964), Seginer (1966), Soil Conservation Service (1977), Sueddon (1985), Temple (1992), Ichim & Radoane (1994, 1998). Most of the prediction models have generally been developed as regressions (simple and multiple correlations), using the following independent variables: the catchments area at the gully headcut; terraced area, out of the total catchments area at the gully's headcut; annual rainfall measured at the gully headcut catchments; soil features (content of clay) at the gully headcut; gully's length at a certain moment; distance and relief energy between the gully's headcut and the highest altitude in the river basin; valley's slope upstream of gullies' headcut. According to the specialized literature, the rate of gully headcut advance varies very much from a region to another, as well as within the same area. In Romania, the annual rate of gully headcut advance varies as follows: Colinele Tutovei region, 0.5 – 2.0 m/year (Motoc et al., 1979); Slanic-Buzau region, 1.4 – 5.4 m/year (Mihaiu, 1980), and, respectively 1.75 – 6.70 m/year (Mircea, 2000); Barlad Plateau region, 12.5 m/year (Ionita, 1998), etc.

RISK INDICATORS FOR GULLY EROSION DEVELOPMENT

This category of indicators is a very important and complex one for the gully development. Generally speaking, natural risk (climate, geology etc.) does mean the probability to occur a certain natural event that produces damages to the people or affects their activities. In the specialized literature concerning water erosion and landslides there is frequently used the notion of risk rather than hazard. There are used for gully erosion the following indicators:

- *gullies advance in length*, (m/year);
- *gullies development in width*, (ha/year);
- *gullies development in volume*, (m^3/year).

In Romania, M. Motoc (1999), has proposed a series of *risk indicators* concerning gully erosion, as follows:
1. *Rate of fragmentation of gullies' watersheds and jeopardize of some social-economic objectives located upstream of gully headcut,* such as: civil constructions, transportation ways, water or gas/petrol pipelines, etc.:
- it is calculated by the ratio $R_{ar}/S_{r\ vf}$, (m/year/ha),
where R_{ar} is the yearly rate of gully headcut advance, in m/year, and $S_{r\ vf.}$ is the gully headcut's watershed, in ha.
2. *Risk of gully development in width*:
- it refers to the yearly rate of lands loss, in ha/year;
3. *Risk by inundation and/or siltation of the lands or some social-economic objectives downstream*:
- it does refer to the annual damages, financially evaluated, that are produced downstream of gullies on agricultural lands or even to some social-economic objectives.

ANTI-EROSION WORKS

Human intervention in erosion works must answer in all cases to the specific conditions of each unit, being necessary studies and an elaborate research on the development of erosion and river network, both under natural conditions and after improvements. In an arrangement work of a hydrographic basin the volume necessary to combat soil erosion may vary from 20% to 60% depending on the importance of the objectives that must be protected. The gully from Tatarului Valley has a concrete check-dam of 3.5 meters high, which was identified at the distance of 32 meters from gully's headcut (Figures 3 and 4).
This check-dam was not silted on its first 1.6 meters in the year 1997, and today - because of its drain holes that height has grown to almost 2 meters. In those seven years the length of this gully grew up upstream rapidly from 32 to 43 meters (Figures 3), despite the fact that the discharge of the gully's headcut has been decreasing a little bit in time.

Figure 3 Gully's headcut of Tatarului Valley, Sub-Carpathians Curvature region, Buzau County, year 1997

Its evolution would have been much greater in time if the gully and its side walls well as the surroundings wouldn't have been forested with acacia species. The acacia trees have spread their roots on the entire perimeter, which caused in this way a slower evolution of the gully, as it can be seen in Figures 2.
Also, as it can be seen from the Figures 5 and 6, the gully's width has not been modified significantly in time. Tree roots have successfully stopped the evolution of the gully on its width. One aspect that should be mentioned here, that applies to Tatarului Valley, but not only, is related to the influence of the size and position of the dam's drain holes. Through these drain holes water discharge have started flowing in large quantities washing the alluvia deposited upstream of the check-dam (Figure 3). The dam that was originally fully clogged with alluvia slowly began to be washed and to lose its stability. A factor that helped this phenomenon is the small fragments of wood roots left behind

the dam. Generally many check-dams on the gullies have their drain holes much larger compared to the size of the alluvia that are transiting downstream.

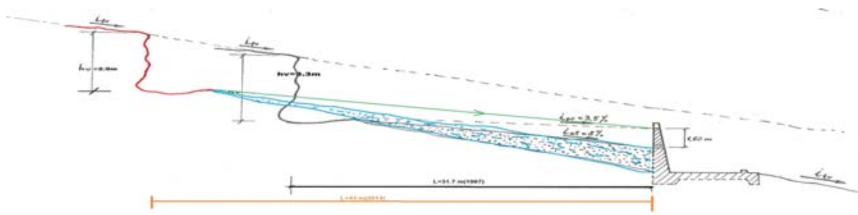

Figure 4 Longitudinal profile in the area of Tatarului gully's headcut, comparison between years 1997 and 2014

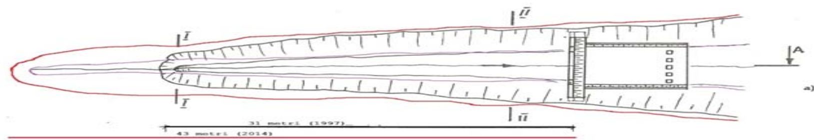

Figure 5 Layout of Tatarului gully's headcut area, comparison between years 1997 and 2014

RESULTS, DISCUSSIONS AND RECOMMENDATIONS

From observations made on Tatarului Valley ravine we have came to the following conclusions and practical recommendations for the design, construction and operation of works made for ravines:

- there are far more effective small height and more frequent transverse works than those that after warping, are creating in some circumstances higher slopes than the natural ones;
- in the first stage of the works, erosion downstream of the dam is more pronounced than the one upstream because the alluvia is deposited behind the dam and the only thing that passes is water with a high kinetic energy;
- the dams are creating low slope areas upstream of them and lowers the kinetic energy of the water but does not prevent the evolution of the ravine to the top;
- apparently dams with small drain holes placed on top of the dam are the most effective, these are the ones that get clogged the fastest.
- longitudinal slope development is uneven between works and is strongly influenced by the works height, the distance between them, by location and by the nature of the transported material. After its fully clogging, dam's longitudinal slope tends to rise and return to the initial slope of the thalweg;
- to avoid the displacement of the works, both permeable and the impermeable ones, during heavy rainfall, it is recommended afforestation where the work is located and in the surrounding areas.

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