LAND DEGRADATION WITHIN THE POJORATA CATCHMENT (TUTOVA ROLLING HILLS)

Bogdan Pădurariu[1], Ion Ioniţă

Abstract. Pojorâta creek is a left tributary of the Dobortfor River, Zeletin catchment, and is located in the central part of the Tutova Rolling Hills. Spindle-like in shape and NNW to SSE oriented, the Pojorâta catchment of 12.5 km^2 stands out in the relief trough the second order structural asymmetry. The right valley-side represents a cuesta backslope looking to the east, while the left one it is a cuesta front facing to the west. The asymmetry of the landforms is also reflected in the spatial distribution of the main present day geomorphic processes, namely: soil erosion is prevailing on the right valley-side and gullying and landslides are typically for the right valley-side.

Keywords: *structural asymmetry, soil erosion, gullying, landslides, Tutova Rolling Hills*

1. Introduction

Located in the central part of Tutova Rolling Hills, as a left tributary of Dobrotfor, the catchment of Pojorâta creek occupies 12.5 km^2, which represents 14% of the Dobtotfor catchment and 3% of the Zeletin basin (Figure no. 1).

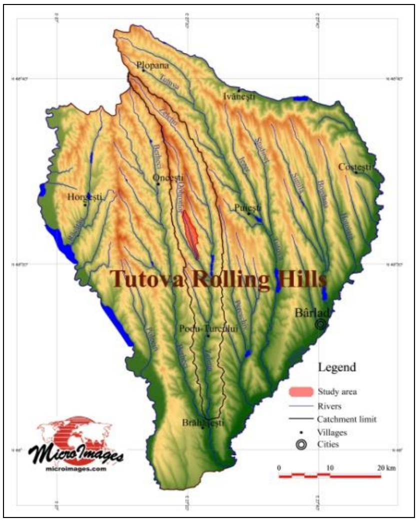

Figure 1: Geographical location of the study area

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Although apparently small, this catchment has some morphometric and morphographical characteristics that can represent a starting point to reveal geomorphological features, both for the studied area and surroundings.

From geological point of view, Pojorâta catchment is developed in geological formations of the Bârlad Depression where outcrop sedimentary layers belonging Chersonian and Meotian (Figure no. 2).

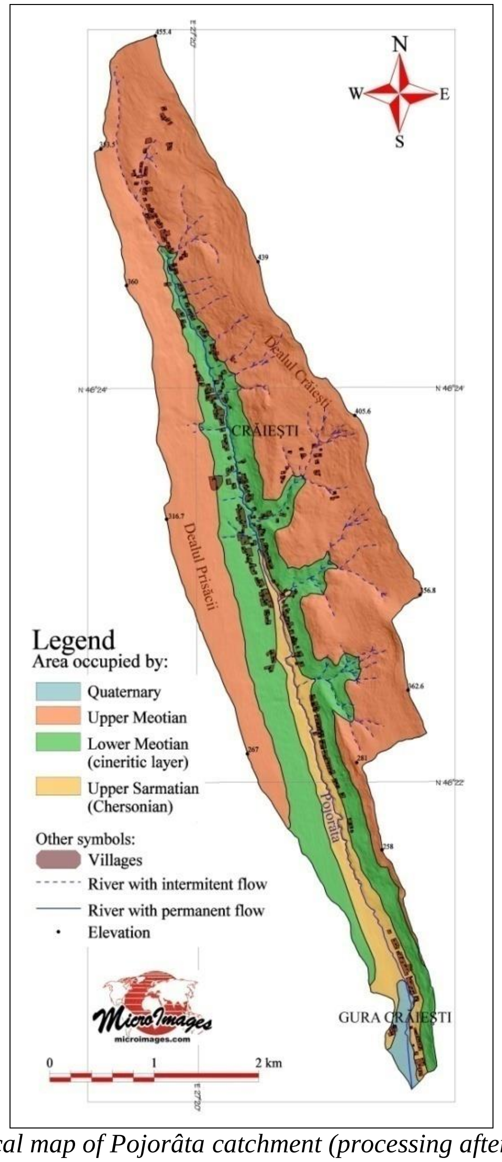


Figure 2: The geological map of Pojorâta catchment (processing after Jeanrenaud P., 1971)

Figure no. 3 shows that most of the strata (90.7%) are of Meotian in age. According to *P. Jeanrenaud* (1971), the Meotian layers are represented by two distinct formations: the lower one, *cineritic-andesitic* located in the lower third of the hill-slopes and the upper one, *sandy-clayey* horizon comprising the middle and upper third of the valley-sides.

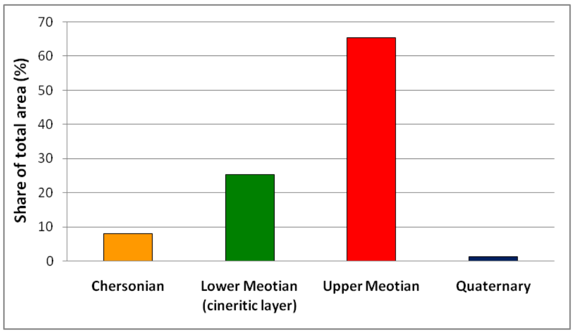
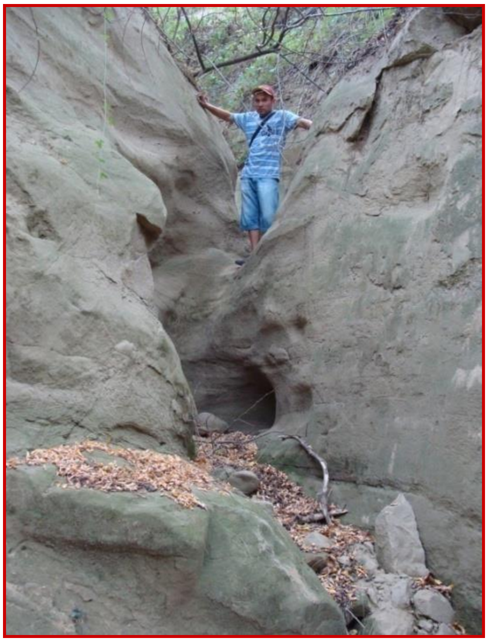
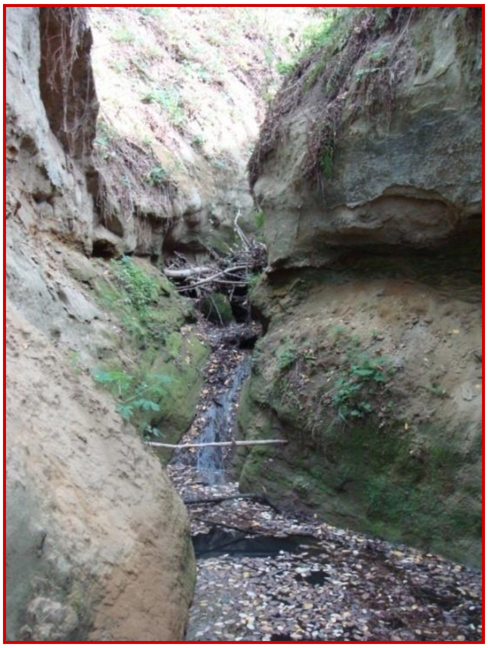


Figure 3: Histogram of the areas covered by different layers

The cineritic formation of 312 ha in size is generally covered by recent, Quaternary formations as colluvia and deluvia. They are mostly highlighted in the gully banks or along the gullies where they can often form small narrow gorge reaches as the ones from Oprişeşti Gully (Figures no. 4 and 5).





Figures 4 and 5: Small gorges developed in the Nuţasca Ruseni cineritic sandstones in the Oprişeşti Gully, SE of Crăieşti (06 October 2012)

The Upper Meotian, deposited in the deltaic facies, outcrops on 805 ha and it is consisting in alternation of clay, sand, sandy-clayey or clayey-sandy seams. The Chersonian deposits appear in the southern half of the catchment and only at the base of the slopes, being generally covered by newer alluvial, colluvial or proluvial formations. They consist of a sequence of cross-bedding clays, sandy-clays and sands deposited in coastal-deltaic facies, generally not fossiliferous (*Jeanrenaud P*, 1966, 1971a, 1971b).

2. Materials and methods

Topographic maps in1:5,000 scale, soil surveys for Motoşeni and Stănişeşti villages undertaken by OSPA Bacău, the aerial photos (flight 2005) and field observations as well have been used for the geomorphological analysis. Also, the ETrex30 Garmin GPS was used to map the Valea Boului gully. All informations have been integrated into a GIS system, ultimately resulting the associated thematic maps from where a number of links and conclusions were drawn.

The morphometric analysis of the landform, based on the Numerical Model for Land (Digital Elevation Model-DEM) and derived from the topographic maps, allowed to assess the hypsometry, the value of slopes and the slope orientation.

The altitudinal ecart of Pojorâta catchment is between 455.4 m in the Crăieşti Hill and 149.5 m at the junction with Dobrotfor, and the average altitude is 283.2 m (Figure no. 6).

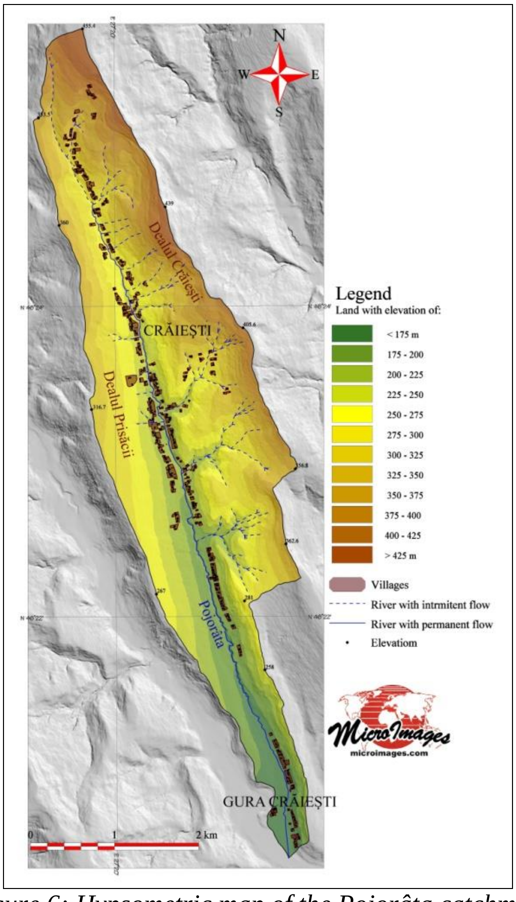


Figure 6: Hypsometric map of the Pojorâta catchment

A slight hypsometric asymmetry can be noticed within the study area as illustrated by Figure no.7. Thus, the altitudes between 150-300 m are prevailing on the right valley-side, while on the left side the altitudes are higher, often ranging between 250-450 m.

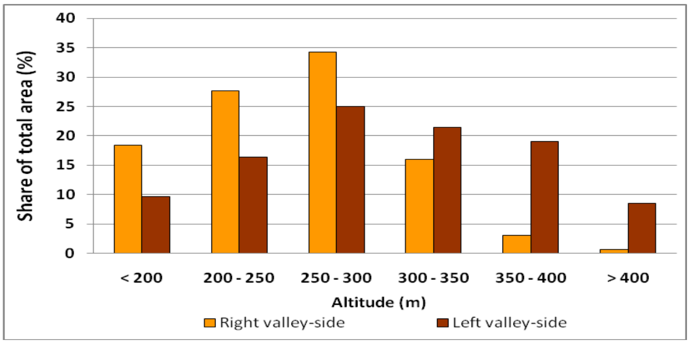


Figure 7: Surfaces hystogram by the altitude classes

The value of the slopes follows the altitudes pattern requiring a more obvious asymmetry. Generally, the slope values over 10 º appear in the northern and eastern part, while the slopes with slope below 10 º predominate the western half of the catchment (Figure no. 8). This contrast between the two main slopes, concerning the slope values, is also illustrated by the Figure no. 9.

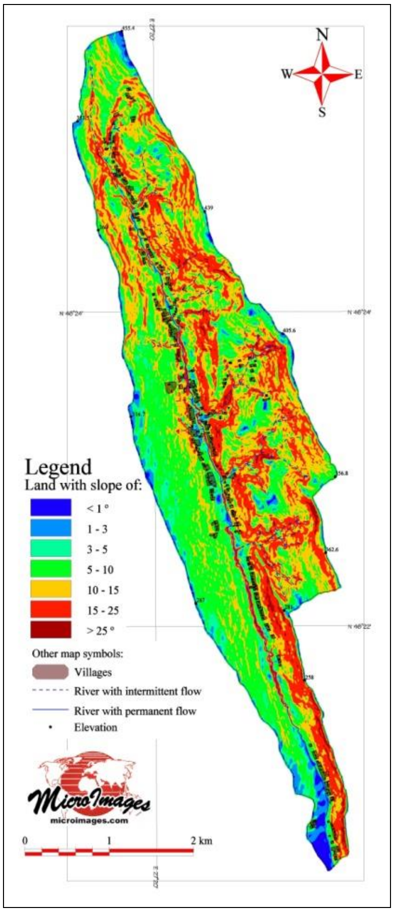


Figure 8: Slope map in the Pojorâta catchment

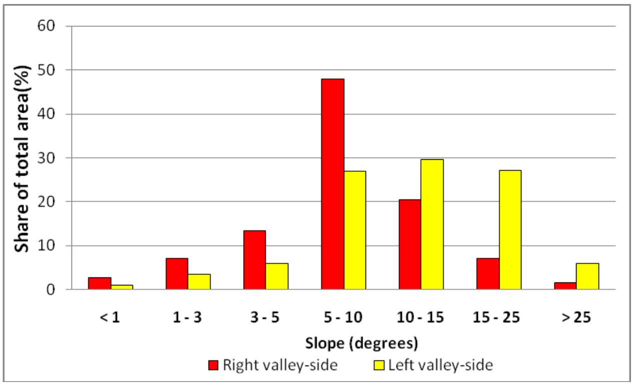


Figure 9: The surfaces histogram by the altitude classes

The unequal distribution of the slopes on the valley-sides is also emphasized by the 55 m medium altitude difference in between. Moreover, that difference is encountered along the two hilltops.

Spindle-like in shape, generally N-S oriented, the Pojorâta catchment exhibits the prevailing of the eastern, western and south-western looking slopes (Figure no. 10).

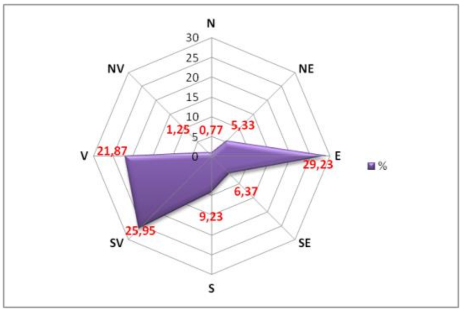


Figure 10: Slopes orientation in the Pojorâta catchment

Land degradation is dependent of other controlling factors, such as climate, hydrology, soil cover and land use.

The *climatic factor*, considered a preliminary one in triggering the geomorphic processes, required by both the temperature and the distribution of precipitation through the year, especially. They put their mark mostly on the agricultural land during spring and early summer when the cultivated plants are under early stage of development. The average amount of precipitations is around 530-550 mm yr^{-1}, but during rainy period it exceeds 750 mm yr^{-1} such as at Onceşti for 1968 – 1973.

The intensity of land degradation is also underlined by the value of sediment delivery of more than 6 t ha^{-1} yr^{-1} as estimated by *Pujina D.* (1997) for the High Tutova Rolling Hills.

Based on the analysis of soil surveys undertaken by OSPA Bacău and the soil classification according to the SRTS 2012 it was possible to found that three classes of soils (Antrisols, Luvisols, and Protisols) are prevailing in the Pojorâta catchment. As to the soil type level, the most common are Anthrosols (33%), Luvisols (48%), Regosols (13%) and Hidrisols (4%).

3. Relief types

The Moldavian Plateau is developed on a monocline geological structure where layers are slightly dipping to SSE. Since the general orientation of the Pojorâta Valley is in accordance with the above mentioned dipping, that means this valley is a resequent one, but it is obvious that its cross-section is asymmetrical and not symmetrical one. According to *Ioniţă I.* (1997, 2000), that asymmetrical feature is associated to the *„differentiated dipping"* N-S and W-E of the layers resulting from the higher neotectonic uplift of the Moldavian Plateau at the junction with the Carpathian Orogen. Thus, the significant asymmetry of Pojorâta Valley is expressed by the western facing cuesta front and the eastern looking cuesta back slope, highlighted by *Ioniţă I.* (1997, 2000) as a *"representative witness for the initial asymmetry"* of the valleys from Tutova Rolling Hills.

The dominant relief type is sculptural (fluvio-denudational) developed in general monoclinal structure. However, the evolution of the landforms controlled by external factors led to the development of some subsequent tributaries on the left side of Pojorâta Valley, such as Oprişeşti Valley, Baştei Valley. They are east-west oriented and succeeded to carv small cuesta apophyses with northern facing front and south looking backslope. Generally, the higher amplitude of the left side of Pojorâta Valley favored the formation of large valley-side gullies that later triggered landslides. Thus, these geomorphic processes resulted in the extension of the eastern half of the Pojorâta catchment. Moreover, the right slope, initially a more extended cuesta back slope and now represented by Prisaca Hill, has been shrunken by the regressive evolution of the Dobrotfor network. Under these circumstances, two-thirds of the northern half of the Pojorâta Valley are covered by cuesta front and the remaining one-third by cuesta backslope.

The prevailing sculptural landforms developed in general monoclinal structure are represented by the interfluvial hilltops (5.9% of the total area) and the slopes, mostly as cuesta fronts or backslopes occupying over 82% of the catchment.

In addition, the accumulative landforms appear poorly extended in the study area as alluvial-coluvial-proluvial glacises (9.4%).

4. Land degradation

The spatial distribution of degraded lands is influenced by the existing topography, the lithologic substratum, the hydro-climatic conditions and land use.

Soil erosion is the process usually developed on the slopes with gradients more than 3º. Given that 94% of the Pojorâta catchment is sloping land, the study area has high potential to soil erosion. The graph in Figure no 11, made by processing data from soil surveys undertaken by OSPA Bacău, emphasizes the predominance of severe, very severe and excessive eroded soils.

The most common are the severe eroded soils with 493 ha (46.5% of the agricultural land) followed by very severe eroded ones with 247 ha (23.3%).

As slope gradient increases, soils with increasingly higher erosion potential occur (Figure no. 12). Although the link slope-erosion is directly proportional one, exceptions are associated mostly to the land use.

Based on runoff plots data collected in the Tarina Valley, Tutova Rolling Hills, under slightly eroded cambic chernozems on 30 years period (1970-1999), *Ioniţă I.* (2000c, 2007) revealed that the average annual soil losses ranged from 7.74 t ha^{-1} for maize and 33.10 t ha^{-1} for fallow, and the soil erosion critical season for the row crops covers two months (May 15-

20 to July 15-20). In turn, the soil loss for the same crops is doubling under severe and excessive forestry soils such as luvosols.

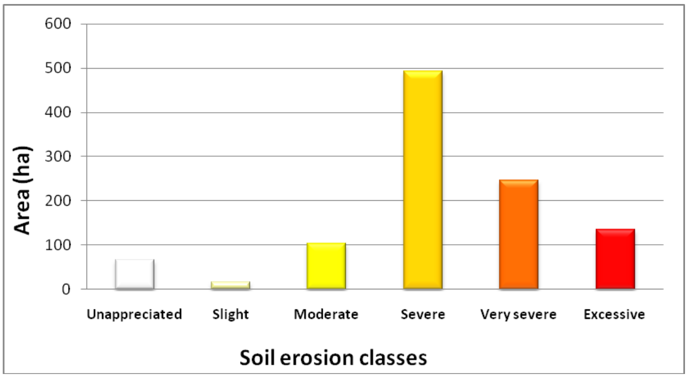


Figure 11: The intensity of the soil erosion in the Pojorâta catchment

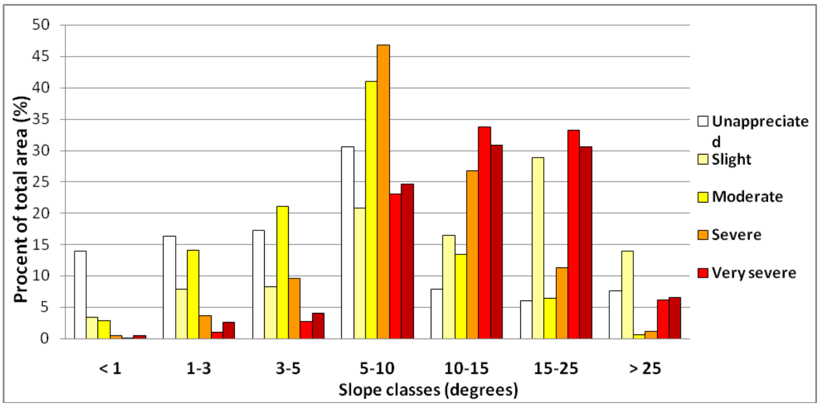


Figure 12: The histogram of surfaces under eroded soils by slope classes

Gullying is the major geomorphic process within the Tutova Rolling Hills area as firstly reported by *Hârjoabă I.* (1968) who consider that gullies are *"one of the most important geomorphic phenomena for the Tutova Rolling Hills, assuming the most important role in the present-day evolution of the region"*.

A number of 70 gullies of different types and sizes have been identified based on the aerial-orthophotos and field observations. They occupy 74.79 ha, which represents 6.07% of the catchment area, a double value than the percentage from Zeletin catchment.

Of these, 69 have been classified as valley-side gullies, generally controlled by the morphology of the catchment. The most developed gullies exceed 10 ha in size, as the Oprişeşti Valley Gully (12.09 ha) or Boului Valley Gully (11.9 ha), while the area of 7 gullies ranges between 1-10 hectares.

The map from the Figure no. 15 illustrates that the gully distribution in the Pojorâta catchment is an asymmetric one, namely: 93% of the valley-side gullies are streatching on the left slope of the catchment and the remaining on the right slope. Thus, gullying has a very significant impact on 6.23% of the left Pojorâta valley-side and only 0.76% on the right valley-side.

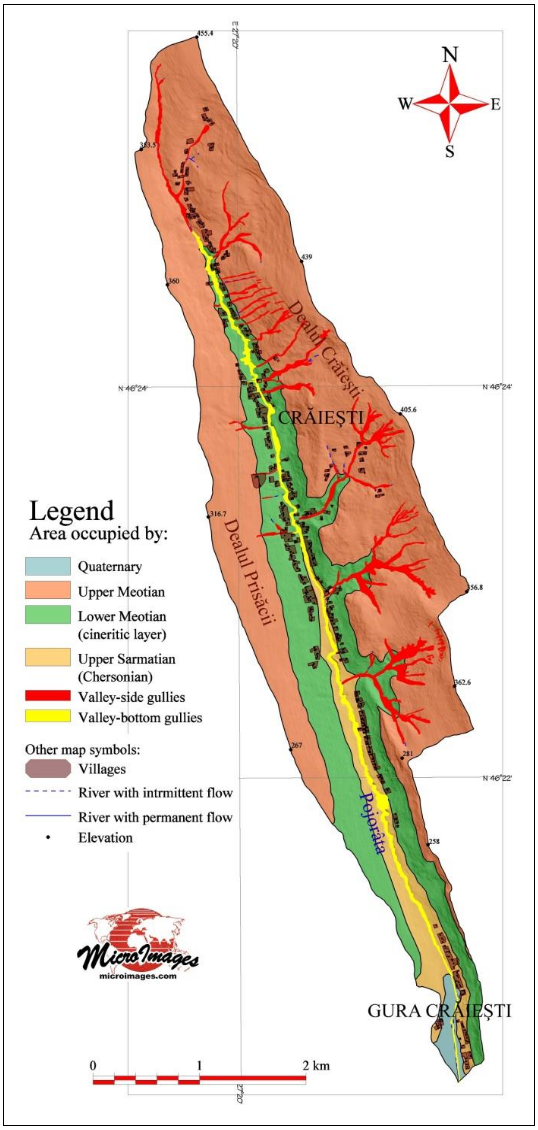


Figure 13. Distribution of the gullies in the Pojorâta catchment

Valley bottom gullies are represented only by Pojorâta gully, a former stream channel deep incised in the alluvial-coluvial-proluvial deposits. It often is of 30-40 m width with high banks, sometimes of 20-25 m.

Where dam structures have been built to control the gullying, behind them there were accumulated sediments delivered by the valley-side gullies, and the cross-section of valley-bottom gully becomes trapezoidal in shape.

Valley-side gullies are the most widespread and occupy two-thirds of the gullyed area, 50.68 ha (68%), compared to the valley-bottom ones with only 24.10 ha (32%).

Amid the slope reaches with increased gradient, often old landslide scarps, there were formed *"grid"* paralel gullies as the ones from Boului (Baştei) Valley at SE of Crăieşti village (Figure no. 14).

Figure 14: Discontinuous gullies on the left Pojorâta valley-side, SE from Crăieşti

To highlight in more details the gullying characteristics from the studied catchment, there have been used a series of measurements using Garmin GPS 30 for Boului Gully (Figure no. 15). Thus, the catchment of this valley-side gully is 95.2 ha. The maximum altitude is 363 m and the minimum 180 m. Inside this small catchment the gullyed area (both continuous and discontinuous gullies) occupies 12.1 hectares which represents 12.7%.

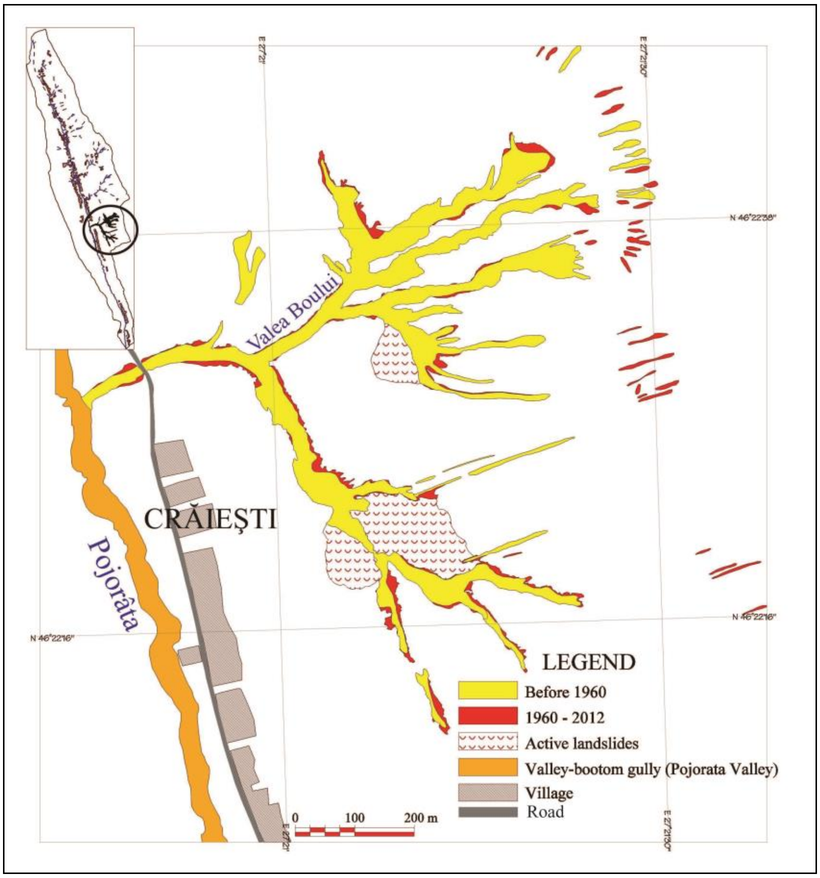


Figure 15: Development of the Boului Gully on the left slope of the Pojorâta Valley

If referring only to the Boului Valley continuous gully, it covered 9.7 ha in 1960 and now extended to almost 11 ha. It is noticed that during 1960–2012, the average annual gully-growth was 246 m^2 yr^{-1}. Given the wetter period of 1968 – 1973 and the forestation made after 1973, it can be deducted that the highest rates of the area gully-growth occurred before this year, now the values being reduced.

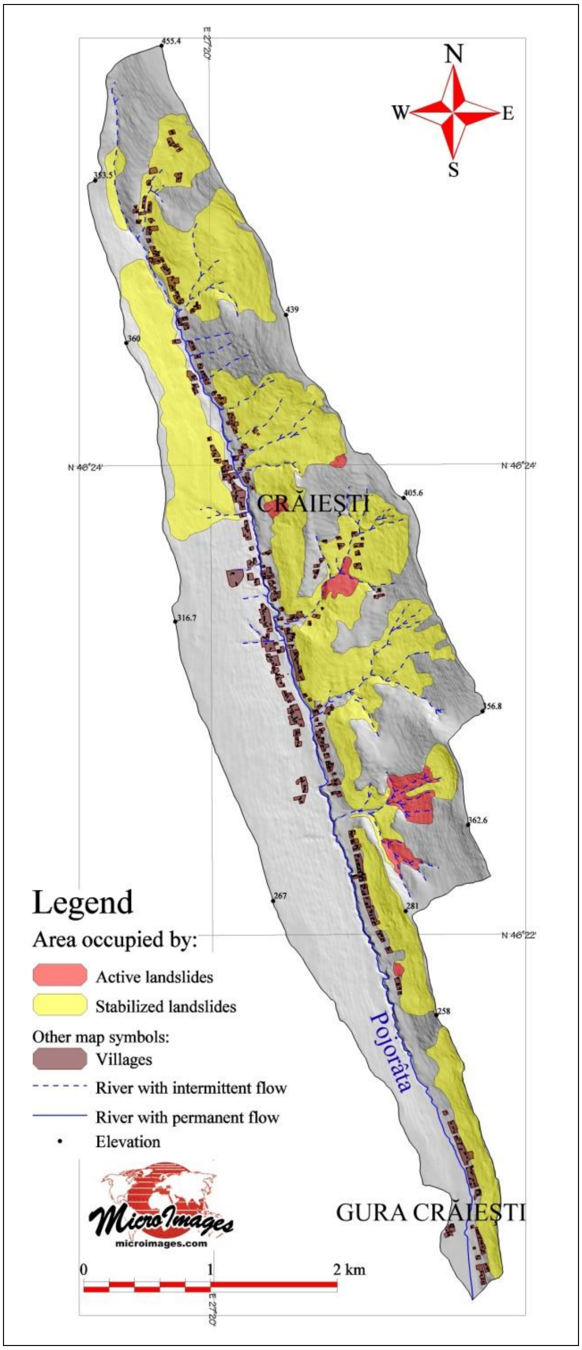


Figure 16: Spatial distribution of the landslides

Successive long lasting measurements, made by *Ioniţă I.* (1997, 2000b) on a series of representative continuous and discontinuous gullies in the Barlad Plateau, showed that the annual gullying regime shows pulses with high amplitude variations. The average retreat of the discontinuous gullies was 1m yr^{-1} and the gullying critical season lasts four months (15-20 March to 15 -20 July).

Landslides cover 476 ha (38.6% of the catchment area) of which the majority (95%) are stabilized landslides. The asymmetry of landforms is also reflected in the spatial distribution of the slopes affected by landslides. Figure no. 16 shows us that the most degraded land subjected to landslides is stretching on the left valley-side representing the cuesta front. Thus, 83% of the slopes at risk of landslides are located in the eastern half of the catchment and only 17% in the western part, mainly on the degraded cuesta back. Spatial distribution of the slopes subjected to landslide and gullying clearly sustains the statement of *Hârjoabă I.* (1968), *"incision through the gullying is the main factor of landslides triggering mechanism"*.The link between landslides and slope is directly proportional, as in the case of gullies, noting that if landslides generally affect land with slopes greater than 5º, gullies can also be installed on land with smaller slopes, as bottom-valley gullies (Figure no 17).

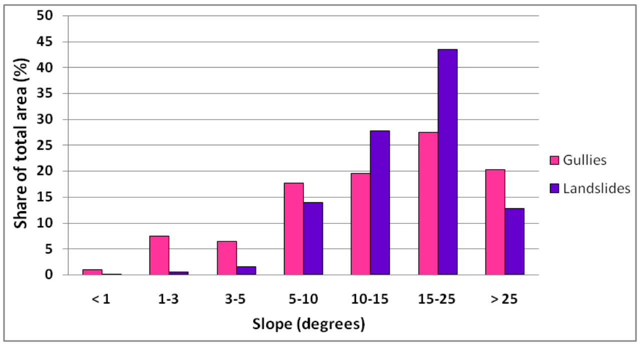


Figure 17: The weight of gullies and landslide by slope classes

Most of the land degradation trough gullying and landslides are spread in the Meotian layers, especially on the sandy-clayey Upper Meotian (Figure no. 18).

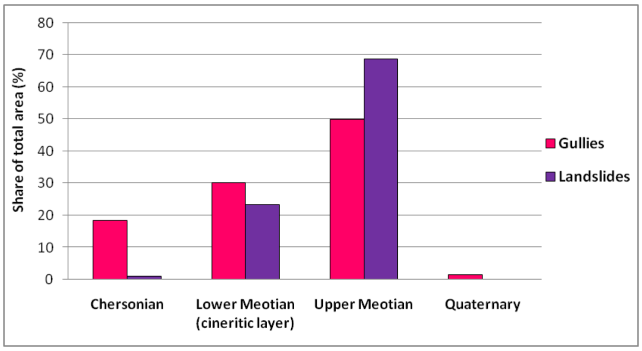


Figure 18: The link between gullies, landslides and geologic bedrock

Geomorphic characteristics of the landscape is reflected in the spatial distribution of degraded land. According to the graph from Figure no 19, the cuesta fronts are the most affected landforms by gullying and landslides, followed by cuesta back slopes. Thus, 46.20% of gullies and 74.41% of landslides are spread on the cuesta fronts and only 18.92% of gullies and 26% of landslides occur on the cuesta back slopes. If landslides occur only on the two mentioned landforms, gullies develop also in the alluvial-coluvial-proluvial glacises (30.26%).

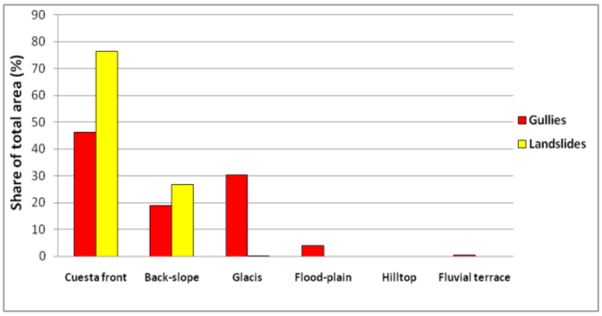


Figure 19: The link between gullies, landslides and landforms

Conclusions

Land degradation by erosion and landslides is a major environmental threat within the Pojorâta Valley from Tutova Rolling Hills. Its distribution and development depends particularly on the landforms and land use. The left valley-side representing a western-looking cuesta front is at great risk of soil erosion, gullying and landslides. Thus, most eroded soils and 93% of the areal gully-growth and 83% of the slopes subjected to landslides are located on this cuesta front.

Ac k n ow l e d g e m e n t s

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