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Gully erosion and associated risks in the Tutova basin – Moldavian Plateau

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Abstract: The present study approaches gully erosion in Tutova basin (south-central part of the Moldavian Plateau, Eastern Romania), mainly with the help of GIS and remote sensing by using the TNTmips 7.3. software. For this purpose a GIS was created, that integrates the Digital Elevation Model, geologic and morphometric maps, climatic and soil data, land use information and others. The assessment of risks associated to gullying has monitored several indicators, grouped as follows: gully-head advance and probability of affecting objectives located upstream; dynamics of gully banks; areal gully growth and loss of agricultural land; flooding and sedimentation of the land or social and economical objectives situated downstream the gully.

Keywords: gully erosion, GIS, geomorphologic risks, Tutova basin

Study area

The studied basin (68,594 hectares) represents the backbone of Tutova Hills, from the south-central part of the Moldavian Plateau, Eastern Romania (Fig. 1).

The lithology of the region is represented by Upper Miocene and Pliocene layers mainly consisting of sands, sandy clays and clays (Jeanrenaud 1971). The general monocline structure accounts for the development of the cuesta relief, implicitly for the mor-

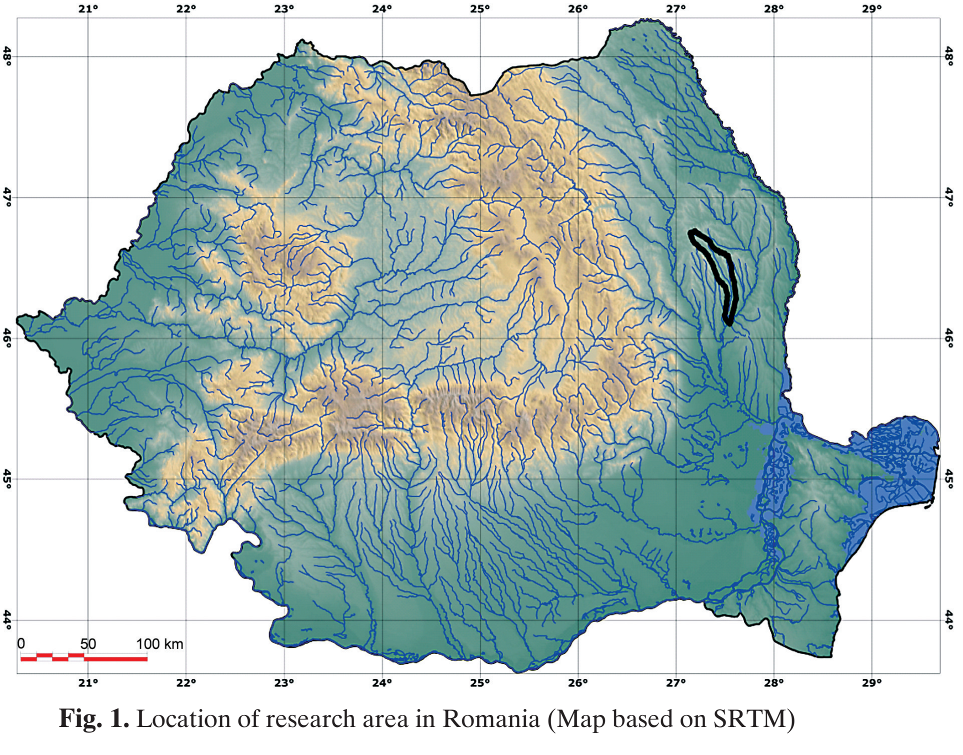

Fig. 1. Location of research area in Romania (Map based on SRTM)

phologic, morpho-dynamic and land use asymmetries (Ionita 2000). The dominantly sculptural landforms, with higher fragmentation in the middle and upper basin, sustain the runoff through declivity or relative altitude (fragmentation depth or relief energy).

The temperate continental climate, sometimes excessive, favors and maintains gullying processes, mainly through two distinct aspects: the frost-thaw alternation from the cold season of the year and the heavy rainfall in the warm one. From a bio-pedologic viewpoint, two aspects are important: the reduced percentage of forested surfaces of 20.5% (Fig. 2), in comparison to the normal bioclimatic equilibrium conditions, in which forests would occupy 65–70%, and the high percentage of eroded or high erodible soils. These equilibrium conditions were appreciated considering the soil properties (Niacsu & Stanga 2006, Stanga 2009).

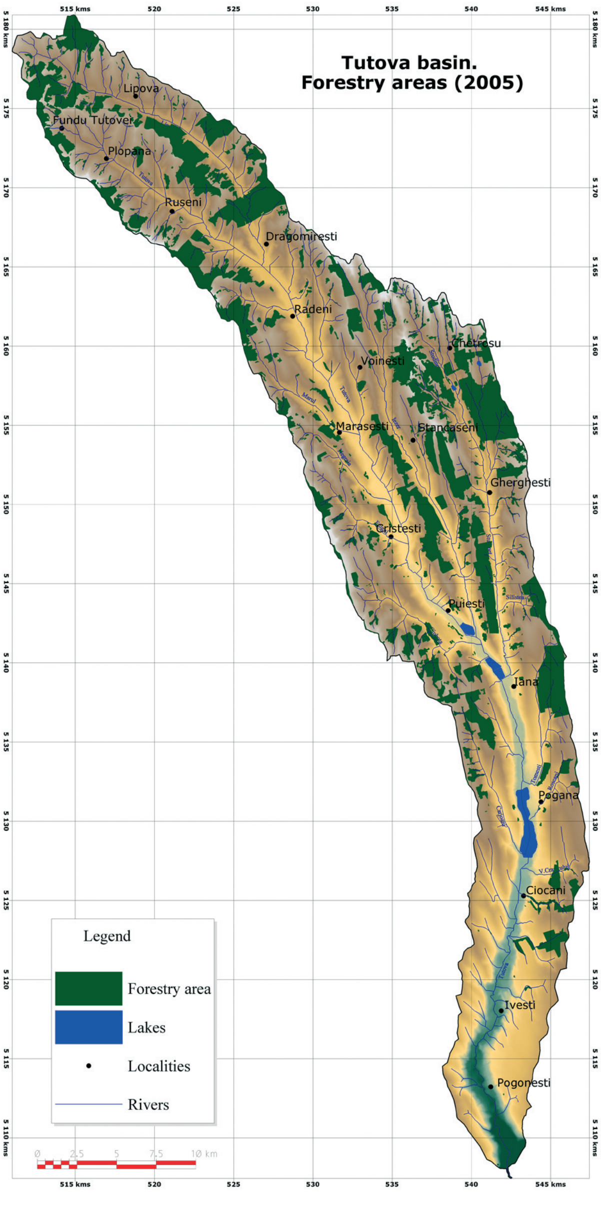

Fig. 2. Tutova basin. Forestry areas (2005)

The agriculture of the area is characterized by a faulty land use, with an "*atomization*" of the agricultural farms numbering about 45,000 parcels, with an average surface of 0.7 ha, and the frequently up and down-slope farming (Stanga 2009).

Materials and methods

The present study approaches gully erosion in Tutova basin, mainly with the help of Geographical Information Systems and remote sensing by using the TNTmips 7.3. software. These data have been accompanied by hydrological and climatic data or laboratory analyses, so as to establish interactive or causality relationships. For this purpose a GIS was created, that integrates the Digital Elevation Model (DEM), geologic and morphometric maps, climatic and soil data, land use information and others.

The spatial data processing (1:25,000) has been conducted in TNTmips7.3 (license obtained through CEEX 756/2006 grant). The statistical analyses have been conducted in Microsoft Office Excel 2003.

Results

Based on the aerial photos (2005 edition, 1:5,000), gullies whose area exceeds 50 m^2 have been delineated and inventoried. There are 1828 gullies with an average area of 0.391 hectares, but with a very different extension, ranging between 50 m^2 and 29.51 hectares. In relation to the total area of the basin, the characteristic spatial density is 2.67 gullies km^{-2}.

It must be noted that there are many gullies whose active channel exceeds ten hectares: Crang (29.11 ha), Carjoani (26.11 ha), Roscani (22.52 ha), Ciubota-Balaur (21.69 ha), Fundatura-Rotari (16.92 ha), Gheltag (13.38 ha), Silistea (10.73 ha) etc. Besides these giant gullies, there are many others, smaller but tightly concentrated on the slopes that are strongly affected by erosion in the last twenty years (Fig. 3).

The correlation between gully distribution and the characteristics of erosion controlling factors was assessed through multilayer analysis. Subsequently, the land susceptibility to gully erosion was established according to this correlation. The most suggestive example is offered by the potential energy of relief, which can be assessed by means of fragmentation depth or the relief relative altitude. This indicator expresses the degree of valley deepening depending on the local base level.

Although rarely used, this parameter doesn't show only the altitude difference, but it also suggests the declivity and the slope length (the mathematical laws in the right triangle). It was determined in TNTmips GIS software and the program calculated the altitude difference (the fragmentation) for all pixels corresponding to each 0.25 km^2 (500 m × 500 m) from the studied area (compare Fig. 4).

In this way, we can appreciate the terrain susceptibility to gully erosion considering three aspects: slope length, slope declivity and relative altitude. The percentage of each step of relative altitude is illustrated in Fig. 5, while the percentage of gully areas for such steps is presented in Fig. 6. In fact, 52.81% of gullied areas are concentrated in steps 4-5 (60–100 m relative altitude).

It is very significant the direct relation between the relative altitude and gully distribution (R^2=0.76).

The assessment of risks associated to gullying has monitored several indicators, grouped as follows: gully-head advance and probability of affecting objectives located upstream; dynamics of gully banks; areal gully growth and loss of useful land; flooding and sedimentation of the land or social and economical objectives situated downstream the gully.

Overlaying the vectorial strata representing villages and gullies, 217 gullies have been identified inside the village area. In some cases, major risks are induced by the gully-head advance as shown by the case study no. 1 "Fulgu village". In other situations, the major risk is due to the high dynamics of gully banks as illustrated by the case study no. 2 "Silistea village".

The third aspect refers to the sedimentation within the downstream areas.

Most frequently, this process affects roads, bridges and culverts, but sometimes even households or other important buildings could be at risk, as presented in the case study no. 3 "Tomesti village".

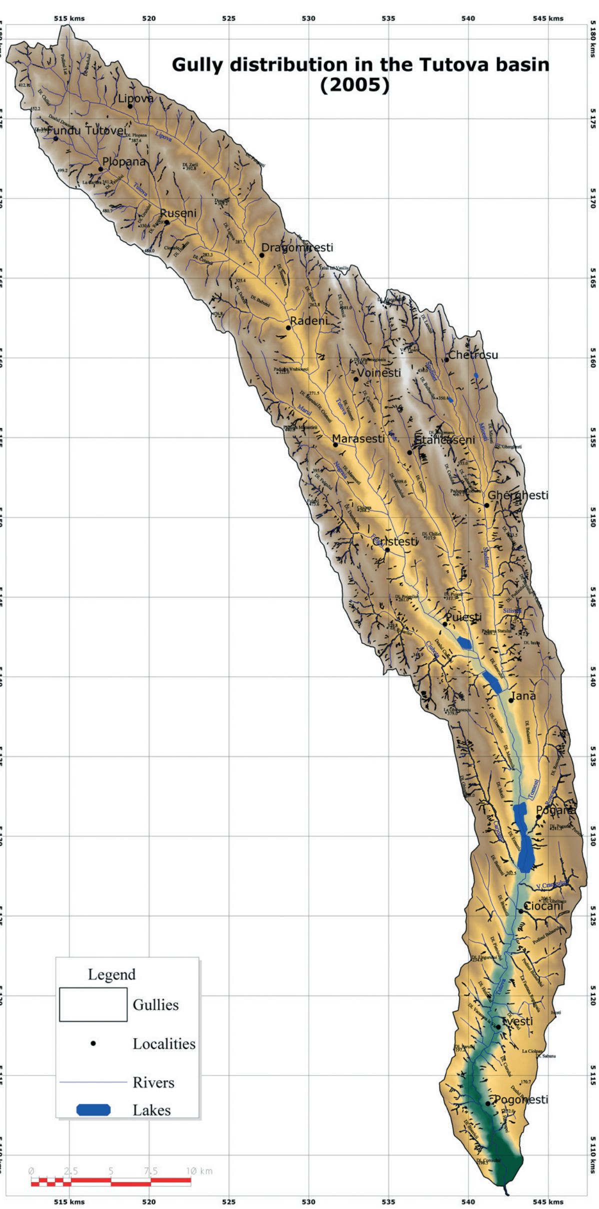

Fig. 3. Gully distribution in Tutova basin (2005)

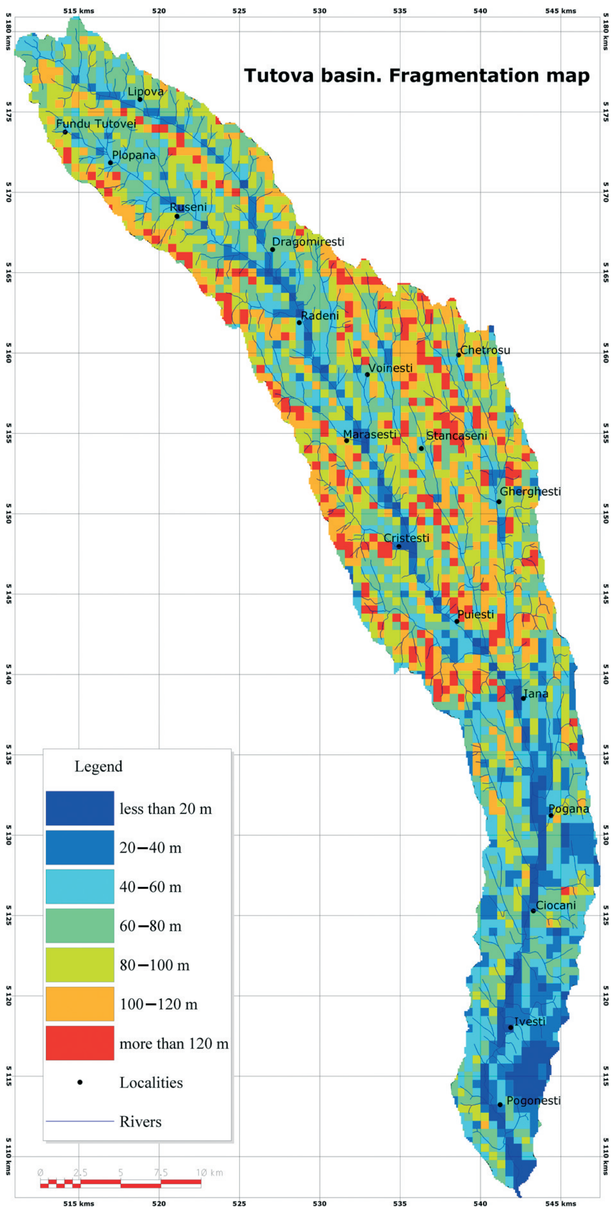

Fig. 4. Tutova basin – fragmentation map

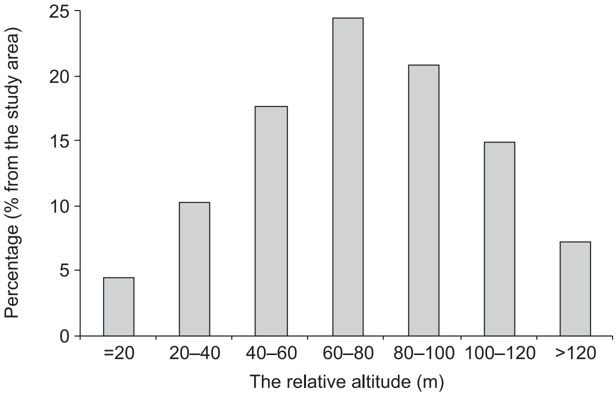

Fig. 5. The percentage of relative altitude steps

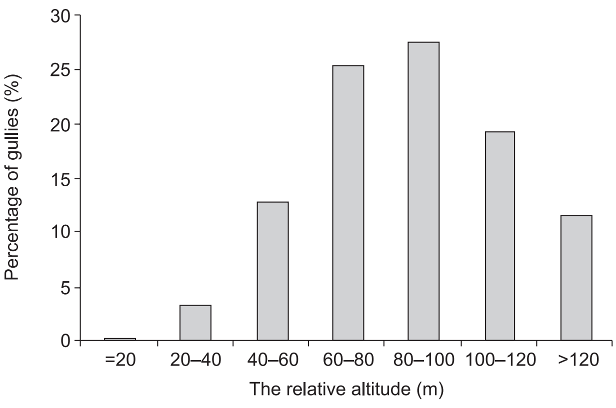

Fig. 6. The relation between the gully distribution and relative altitude

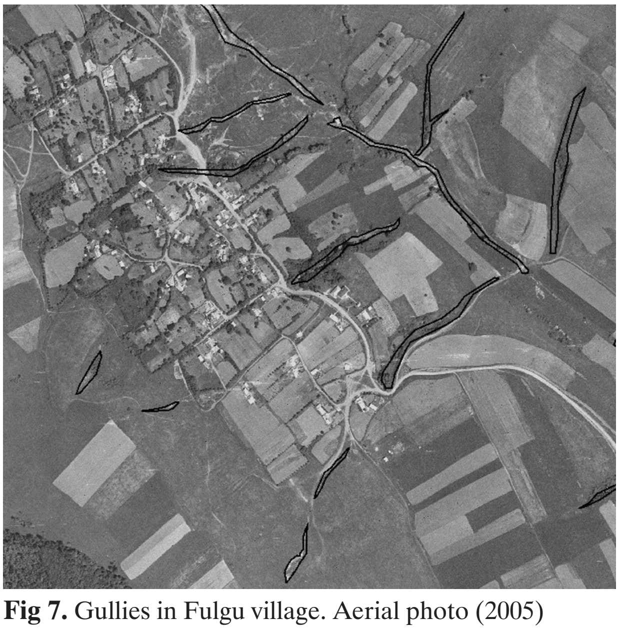

Fig 7. Gullies in Fulgu village. Aerial photo (2005)

In the case study no. 1, the Fulgu village is placed in the source area of a small catchment (central part of study area), being crossed by three active gullies. In the last twenty years, the gully-head advance determined successive changing of the only one access road, sometimes by crossing the gully channel, as we can see in the Fig. 7.

The case study no 2 presents the Silistea village, which is placed in a drainage basin (624 ha) developed on a typical cuesta forehead. The sandy rocks and the impressive relative altitude (almost 250 meters) sustain an active morphogenesis. In the same time, the circularity of the basin allows a rapid and significant runoff that explains moreover the depth of the main gully (7–15 meters).

The deforestation of gully channel and banks of the gully in the last ten years caused the reactivation of geomorphologic processes. The major risk is amplified by the high vulnerability of the households (Fig. 8) built near the gully banks (sometimes at 3–10 meters distance). As a suggestive example, in the summer of 2006, after a rainy period (625 mm in May – August, more than the rainfall annual average of the region), several families had to be evacuated because of the gully banks crumbling.

The case study no. 3 shows the situation of Pietrosul Valley whose drainage basin is located in the south-central part of Tutova basin. The outlet of this gully system is situated in Tomesti village, in a built area. The school and three households are very exposed, being situated on the alluvial fan (Fig. 9).

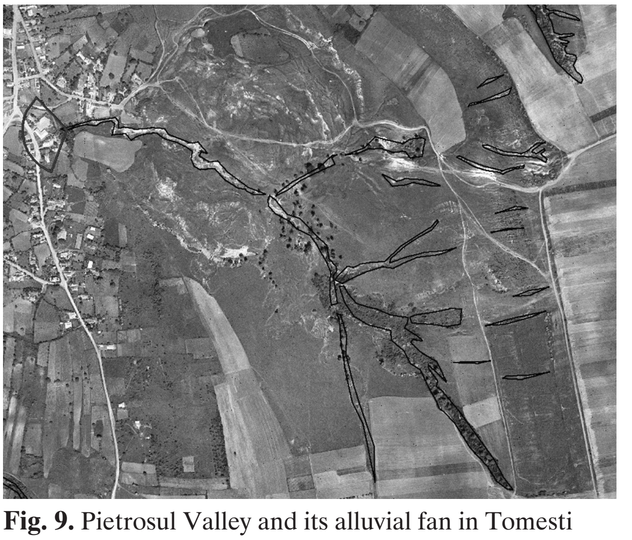

Fig. 9. Pietrosul Valley and its alluvial fan in Tomesti

The risks are amplified by the fact that the basin is completely deforested and strong deepening of the main gully sustains landslides that bring in the gully channel more and more material to be removed by runoff.

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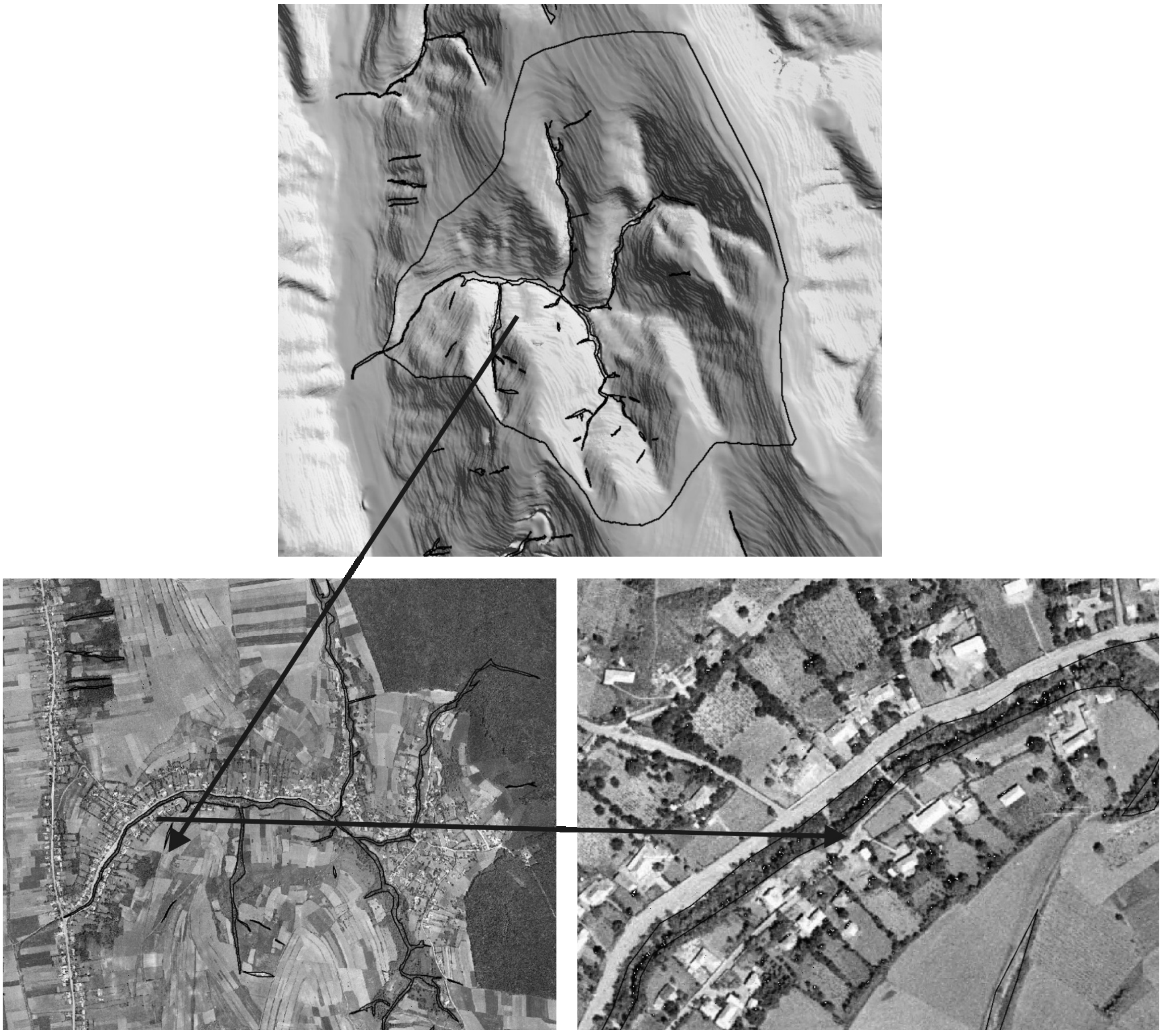

Fig. 8. Silistea basin and rural households highly exposed to gully banks dynamics

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