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# Relief, Support for Rural Communities Development in the Upper and Middle Sectors of the Strei Valley

Ștefania MANEA<sup>1</sup>, Virgil SURDEANU<sup>2</sup>

<sup>1</sup> "Decebal" National College, Deva, ROMANIA

<sup>2</sup> Babeș-Bolyai University, Faculty of Geography, Cluj-Napoca, ROMANIA

E-mail: [anemaria\\_manea@yahoo.com](mailto:anemaria_manea@yahoo.com), [surdeanu\\_v@yahoo.com](mailto:surdeanu_v@yahoo.com)

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## ABSTRACT

The upper and middle sector of the Strei valley falls almost entirely within the Southern Carpathians area. With a general form of a triangle, bordered to the south by the Retezat – Godeanu - Țarcu Mountains, to the west by the Poiana Ruscă Mountains and to the north-west by the Șureanu Mountains, and with an area of over 1,500sq.km., it stands out as a well individualised natural entity. From the geomorphologic point of view, it is a very complex one with landforms characterised by a diverse morphology, morphometry and morphodynamics. The predominantly rural population (10 communes polarized by one town) has properly assessed each site, using it according to the historical, cultural, economic, social and technological context, especially if we take into consideration the fact that it has been humanized since ancient times. The relief has always been support for the development of the rural communities and the major objective of our paper is to reinforce this idea. As we deal with one environmental component which has to be analyzed in relation with the other environmental components, we suggest an investigation methodology.

## 1. INTRODUCTION

The upper and middle sector of the Strei valley, covering over 1.500 sq.km, is a very complex geographical entity, well individualized, comprising the south-western extension of the Șureanu Mts. in the Hațegului Depression, the northern part of the Godeanu- Retezat Mts. and the south-east of the Poiana Ruscă Mountains (fig. 1).

From the administrative point of view, it is a predominantly rural area. The only small town, Hațeg, polarizes the 10 communes (G-ral Berthelot, Răchitova, Densuș, Sarmisegetuza, Râu de Mori, Totești, Sântămăria-Orlea, Sălașu de Sus, Pui and Baru), which are entirely included within its boundaries (fig. 2).

At 2002 census, the population was 35.708 inhabitants. Most of the communes have less than 2000 inhabitants (G-ral Berthelot, Răchitova, Sarmizegetusa

etc.). Those with over 2500 inhabitants have 9-12 villages (e.g. Pui, Râu de Mori, Baru etc.) and an agro-industrial character. Along time, the geomorphological entities, entirely or partially included within its boundaries, have been subject for many studies from different fields of activity that have revealed aspects regarding its geology, paleogeography [0, 0], geomorphology [0, 0, 0, 0, 0, etc.], tourism [0, 0, 0 ], etc. The relationship between the population and the settlements from Hațegului Land, which overlaps the study area, and the landforms has been analyzed for the first time by *Vuia* [0]. Other studies, referring either to the depression [0, 0], or the mountainous areas [0], focussed on the ways in which the habitats adapted to the restrictions of the main components of the natural environment. But none of them had managed to accomplish such a thoroughly analysis as the one made by *Popa* [0, 0].

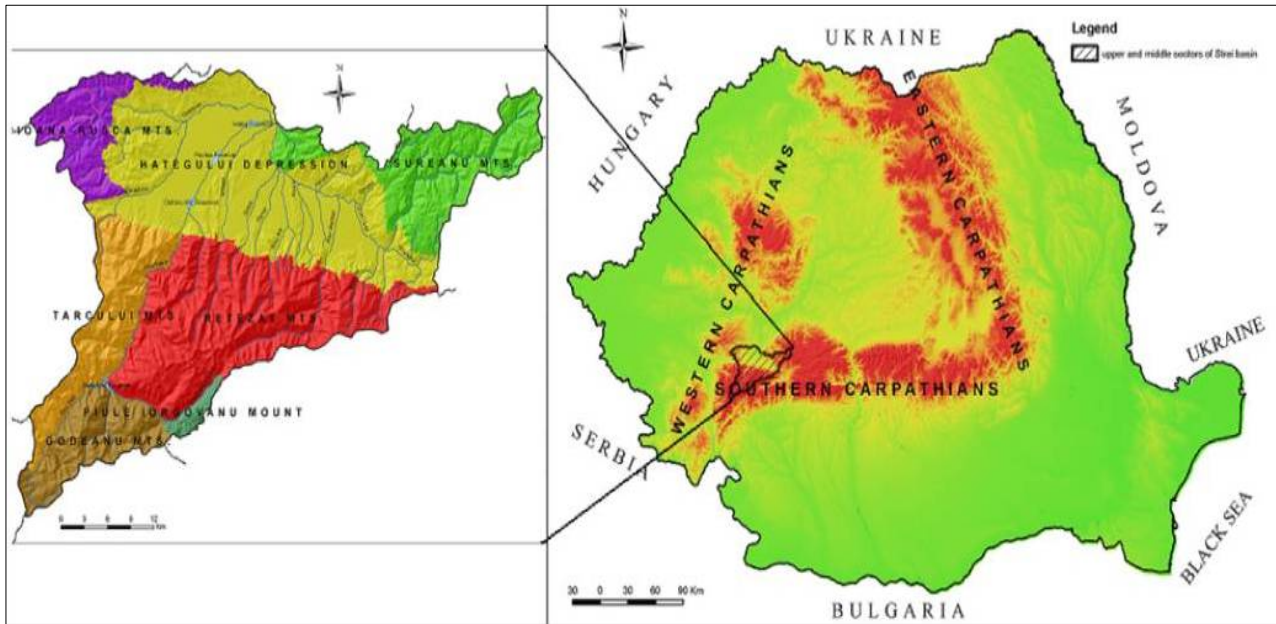


Fig. 1. Study area location.

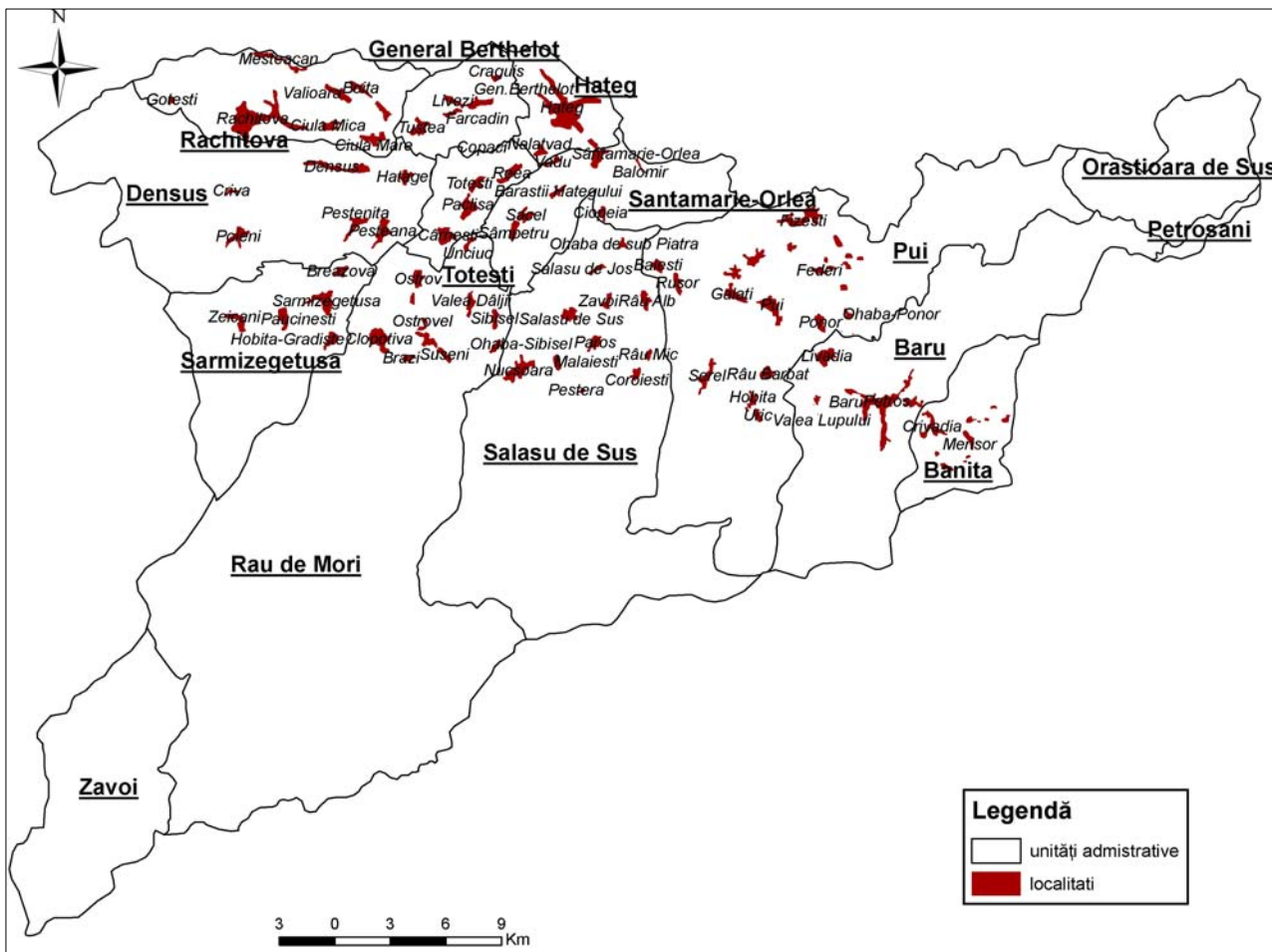


Fig. 2. Upper and Middle Sectors of the Strei Valley. Administrative Units.

The author presented the rural reality in its temporal dimension, analysing the habitat - relief relationship and establishing a typology of the

settlements according to the landforms (floodplains, terraces, slopes, interfluves etc.).

## 2. METHODOLOGY

The relief is the first environmental component on which we act as it is the support not only for the other environmental components, but also for the economic, social and technological activities. Through its functions (i.e. defending, touristic, habitat, natural and administrative boundary etc.), it is a “key factor” in land use and making decisions in territorial planning.

That is why the major objective of this study is to find out whether *the relief is or not support for the development of rural communities in the upper and middle sectors of the Strei valley.*

Under these circumstances, we have to:

- establish a proper investigation methodology

(fig. 3).

The analysis of the way in which the topography urges the communities’ development, both in space and in socio-economic plan, has to be performed under a specific methodology, as we deal with one environment component;

- perform a morphologic, morphometric and morphodynamic analysis, designed to highlight the restrictive or favourable aspects of the landforms;
- analyze the anthropogenic elements in relation to topography;
- make suggestions on certain types of activities the landforms are suitable for and aimed at rural communities’ further development;
- assess, from the geomorphological point of view, the consequences of the suggestions and the appropriate actions that must be taken.

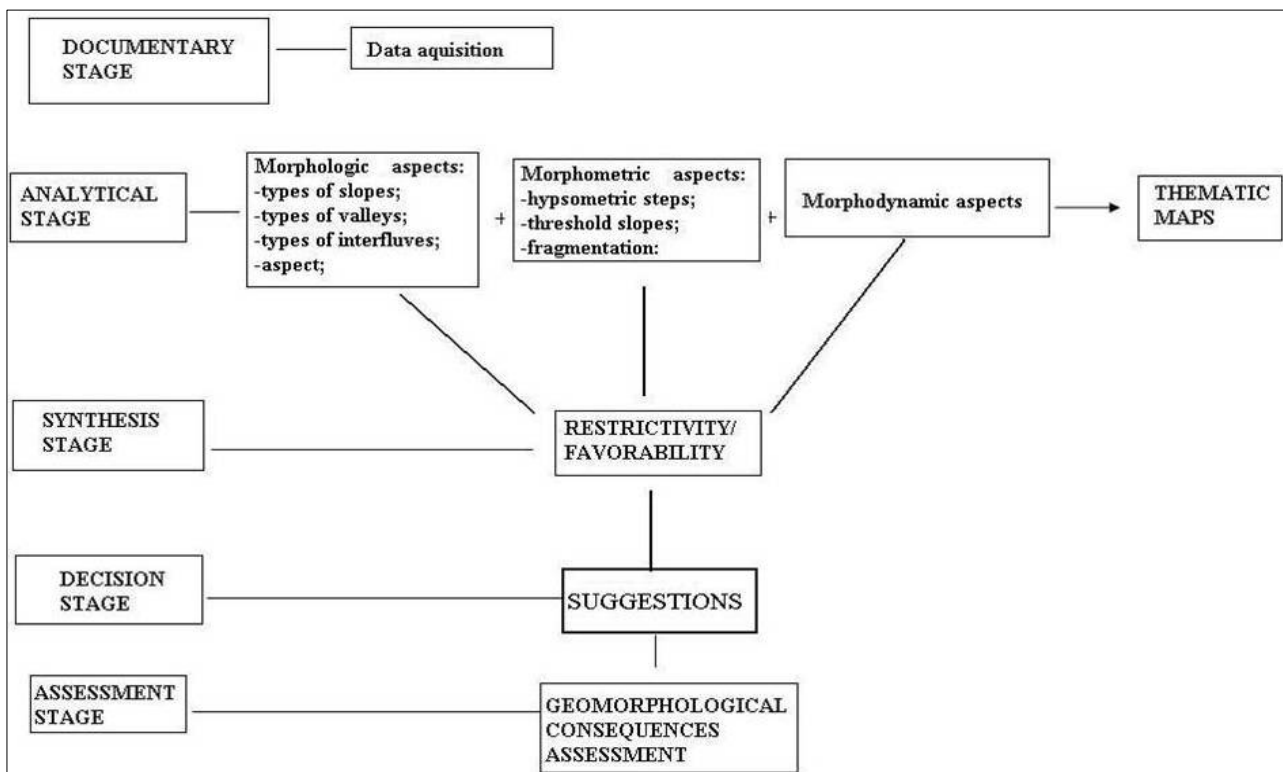


Fig. 3. Investigation methodology.

## 3. RESULTS AND DISCUSSION

The study area is, from the morphologic, morphometric and morphodynamic points of view, a very complex one as it comprises entirely the Hațegului Depression and partly important mountainous areas, which belong to the Southern and Western Carpathians.

### 3.1. Morphologic analysis

According to the *morphologic analysis* the shaded and semi-shaded slopes prevail (59.9% of the total area), restricting the spread of housing and the land use.

However, most of the settlements occupy these slopes because they have low elevations, gradients and fragmentation (Baru, Livadia (Baru commune), Pui, Râu Bărbat, Hobița (Pui commune), Râu Alb, Sălașu de Jos, Sălașu de Sus, Nucșoara (Sălașu de Sus commune) etc.).

Under these circumstances, the population has adapted the buildings and the street network to the aspect to ensure a certain comfort. The street network was built on the north-south direction for all the houses to have a southern orientation or on the east-west direction, with the houses built at a distance one from the other or with the back at the street. Very few settlements occupy the sunny and semi-sunny slopes

(Federi, Fizești (Pui commune), Livezi, Craguiș (G-ral Berthelot commune), Boița, Răchitova (Răchitova commune), Densuș etc.).

### 3.2. Morphometric analysis

From the *morphometric* point of view, most of the territory is *restrictive*. The settlements, the economic activities, the infrastructure are placed within the 285m- 900m elevation limit. Along time, the landforms with these elevations have undergone major changes as a result of building houses and expanding the built areas, building infrastructure, practising agriculture, exploiting resources etc [0].

Most settlements (Hațeg, Pâclișa, Totești, Unciuc, Nalativad, Vadu, Carnesti, Reea, Ostrov, Ostrovel, Hățăgel, Sibişel, Bărăștii Hațegului etc.) as well as the infrastructure are located on the areas with gradients of  $0.1^{\circ}$ - $2^{\circ}$  even if they are subject to floods. The areas with gradients of  $2.1^{\circ}$ - $6^{\circ}$ , overlapping glacia and debris, do not impose restrictions to the location of buildings (Zeicani, Păucinești, Sarmizegetusa, Clopotiva, Râu de Mori, Nucșoara, Mălăiești, Sălașu de Sus, Sălașu de Jos, Coroiști, Râu Alb, Uric, Petros, Ciula Mare, Farcadin etc.). Only few permanent settlements (Fizești, Federi, Răchitova) are located on the areas with gradients of  $6.1^{\circ}$ - $17^{\circ}$ .

The *drainage density* is a parameter that gives a clear picture of the landscape's degree of fragmentation and, therefore, it must be considered not only when analyzing the relief- habitat relationship, but also in planning studies. We obtained a wide range of values from  $<3\text{km}/\text{sq.km}$ . to  $>9\text{km}/\text{sq.km}$ . High ( $6,1-9\text{km}/\text{sq.km}$ ) and very high ( $>9\text{km}/\text{sq.km}$ ) values were identified in the junction basins which are "collecting water markets" (e.g. Pârâul Cald - Pârâul Rovinelor; Strei-Sasu valley; Strei - Jigureasa valley; Crivadia-Rachitei valley; Strei-Bărușor; Râu Bărbat-Murgusa; Varatecului valley - Dreptului valley etc.). In these confluence basins, villages from Baru, Fizești etc. are located. The other villages are located in areas with fragmentation of  $<3\text{km}/\text{sq.km}$  (Hațeg, Nalativad, Vadu, Reea, Totești, Pâclișa, Carnesti, Ostrov, Hățăgel, Râu Bărbat, Râu Alb, partially Pui etc.), of  $6,1-9\text{km}/\text{sq.km}$  (Sibișel, Sampetru, Sacel, Râu de Mori, Suseni, Clopotiva, Răchitova, Densuș, Fizești, Ohaba-Ponor, Crivadia, Merișor etc.). The conclusion we reach when analysing this morphometric parameter is that the high fragmentation levels are reflected in the gathered or scattered structure of the settlements.

Together with the drainage density and declivity, the *relief energy* reflects the degree of evolution of the landscape and where possible equilibrium breaks are in the basin's morphology. Values between  $0-50\text{m}/\text{sq.km}$  characterise the piedmont interfluves. Here, the declivity and drainage density values are low. Consequently, this allowed the

placement and extension of the following settlements: Sălașu de Sus, Sălașu de Jos, Ohaba de sub Piatră, Zavoi, Ostrov, Ostrovu Mic, Unciuc, Carnesti, Pâclișa, Totești, Reea, Bărăștii Hațegului, Vadu, Sântămăria-Orlea, Hațeg, Hățăgel, Râu Bărbat and Ponor. Other settlements such as: Baru, Petros, Livadia, Pui, Galați, Rusor, Râu Alb, Râu Mic, Coroiști, Paroș, Peștera, Ohaba-Sibișel, Săcel, Sâmpetru, Valea Lupului, Tustea etc. lie on surfaces with relief energy of  $50,1-100\text{m}/\text{sq.km}$ . The buildings are placed along the river network in the floodplain on the river terraces.

### 3.3. Morphodynamic analysis

When analyzing the relief, we should not refer only to its morphologic and morphometric aspects as is not an inert structure. We have to take into consideration its dynamics, too. The processes that destabilize the landforms and take out from the agricultural circuit large areas must be assessed following the steps established in a legal framework so as to harmonize the results at the national level and use them in territorial planning studies [0]. To assess the landslide hazard we used the methodology from the *Government Decision no. 447/2003*, that must be followed in any planning study [**Error! Reference source not found.**]. According to the results we obtained, we identified (fig. 4):

- *areas with low landslides occurrence* - have the highest percentage (53.2% of the whole area) and overlay the accumulation piedmonts and the interfluves from the mountainous area protected by vegetation;

- *areas with medium landslide occurrence* - which represent 31.6% of the area and are characterised, from the lithological point of view, by high homogeneity, consisting of hard compact, altered or cracked rocks, covered by unconsolidated deposits. The landslides affect these deposits, fixed with forest vegetation, which is no longer a protective factor, but a triggering one through its weight.

- *areas with high landslides occurrence* - which represent 15.1% of the catchment area and appear on the erosion piedmonts, consisting of semi-hard compact rocks in combination with soft or unconsolidated rocks.

The slopes have gradients of  $6.1^{\circ}$ - $35^{\circ}$ , highly fragmented by debris flows. The landslides recorded are shallow, new, active arising from the development of linear forms of erosion. We also identified old landslides reactivated as a result of an inefficient management (anti-erosion works destruction, overgrazing, conversion of pastures and orchards into arable lands).

To these triggering factors we add: loading slopes with constructions, undermining the slope foot by building roads or by the rivers through lateral erosion etc.



At administrative level, only in Totești commune, the conditions for landslides occurrence are not met. In all the others, the erosion and accumulation piedmonts consisting of packages of rocks with different degrees of resistance to erosion, gradients of 2.1°-6° and 6.1°-17° and modelled by the anthropogenic activities, the susceptibility to landslides occurrence is medium and high. Over 40% of the territory of Bănița, G-ral

Berthelot and Hațeg have a high and very high landslides probability occurrence.

The communes with a predominantly mountainous relief (Râu de Mori, Sălașu de Sus etc.), consisting of hard, compact rocks, or those whose relief is formed of floodplains and accumulation piedmonts, with low declivity and fragmentation values (Densuș), present a low landslide probability occurrence.

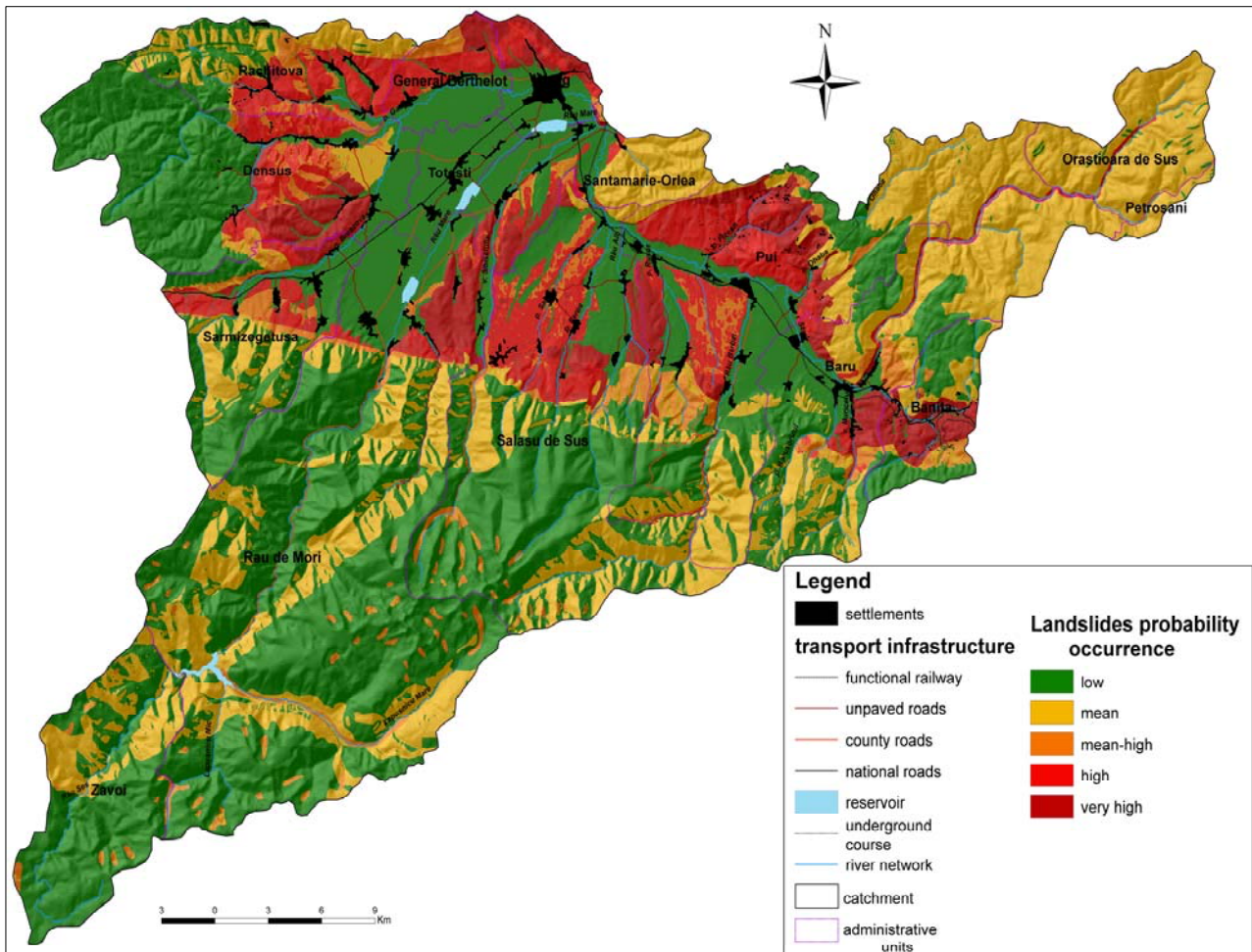


Fig. 4. Upper and middle sectors of the Strei valley. Landslides probability occurrence map.

The anthropogenic elements' *vulnerability* (settlements, transport infrastructure) to landslides was assessed by creating polygons around the selected vectors at a distance of 50, 100, 200, 300, 400 and 500m.

Then, the raster with settlements and transport infrastructure was overlaid over buffer zones, illustrating the areas that could be affected by this process.

Thus, the longer the distance from the landslide area is, the smaller the effects are.

The assessment revealed the fact that several settlements (G-ral Berthelot, Farcadin, Tustea, Ciula Mare, Ciula Mică, Livezi, Livadia, Crivadia, Merișor etc.) and the road and railway in Baru-Merișor sector are most vulnerable to landslides occurrence (fig. 5).

### 3.4. The population - relief relationship

The population - relief relationship is the one between the natural component and the anthropogenic one, which becomes important through the economic, territorial and spatial use of the latter, as well as due to the existing or possible conflictive aspects which result. In this relationship, both components act as well individualized entities, both from the structural and functioning point of view. The population is the one that can give scientific, cultural, historical, esthetical and socio-economic value to landforms, making them geomorphosites [0, 0, 0]. This is the case of the landforms from the karst area (e.g. Crivadii Gorge, Tecuri Gorge, Cioclovina Gorge etc. from the Șureanu Mountains).

Secondly, it is a *conflictive relationship*, both direct and indirect, resulted from overcoming an equilibrium stage. In time, man has been urged to adapt to the topography.

When he did not adapt, he changed the existing situation, but most of the time he triggered disequilibrium, being in conflict with the relief. Illustrative in this respect is the building and expanding of the transportation infrastructure in Baru-Merișor sector, a very dynamic one.

The mitigation works that are performed annually are inefficient due to the high traffic levels [0].

Thirdly, it is a *coordinating and subordinating relationship* in which the relief, through morphometry, stages and limits the habitats and economic activities spreading, as well as urges the building of works of art to facilitate communication.

In relation with the relief, the population is in a double position: *relief user* and *beneficiary of the development strategy*.

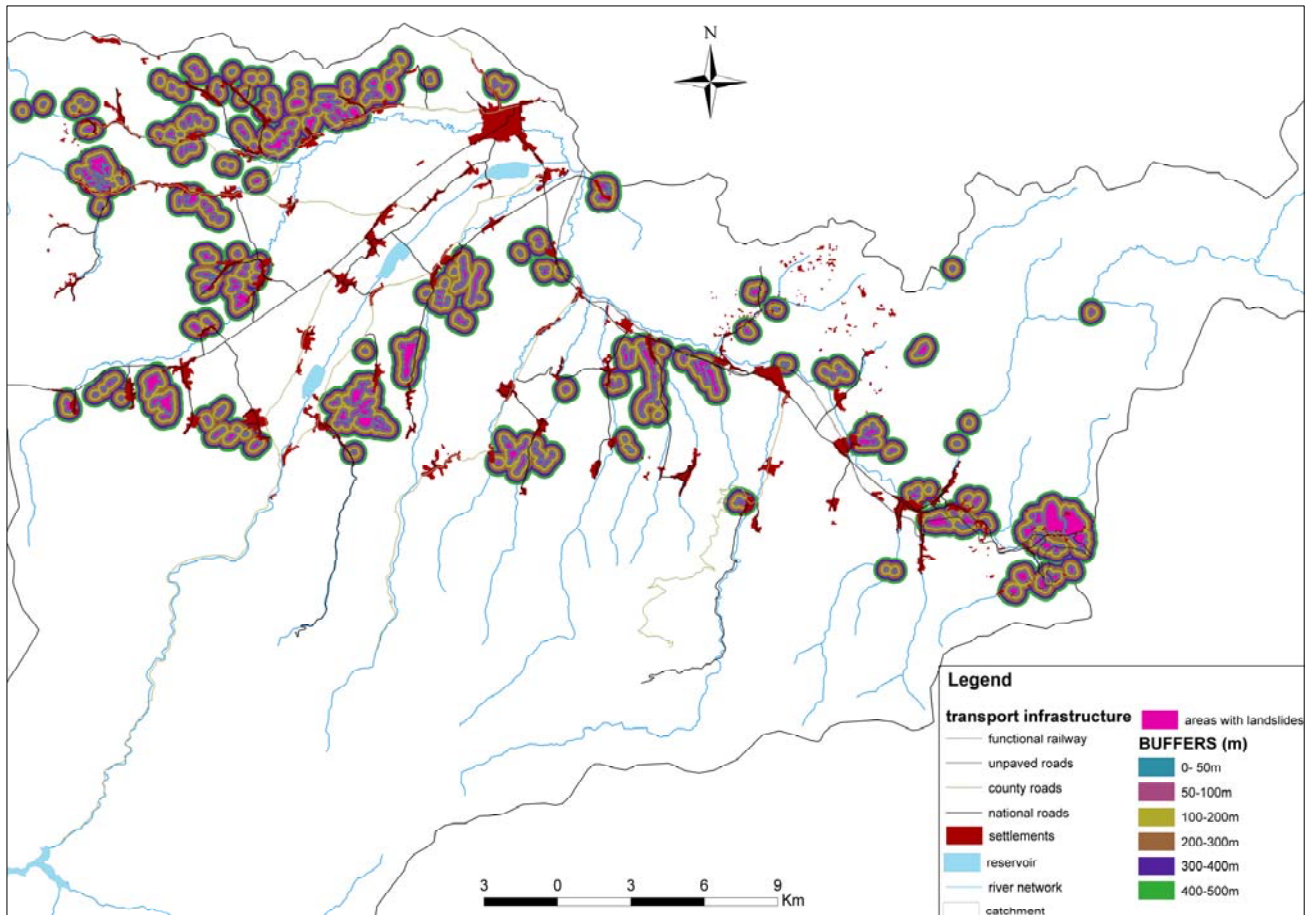


Fig. 5. Upper and middle sectors of the Strei valley. Demographic prognosis.

Therefore, the demographic phenomena, such as: ageing, migration etc., must also be considered to know if there is sufficient human resource to implement the strategy and to benefit from its results.

Analyzing these aspects, we reached the following conclusions:

- the percentage of the young is low, the population growth and migratory rate have negative values; consequently, there will not be enough human resource to use the relief, to implement a development strategy and take advantage of its effects;

- in all the administrative units, the population is affected by a severe ageing process started in 2002; the highest values characterize the communes which are far away from the only urban centre (Densuș, G-ral Berthelot, Răchitova etc.). It is compulsory to perform a

*demographic prognosis* to know if there is enough human resource to implement a future development strategy and benefit from its results. Thus, we estimated the population for 2012 and 2022 (census years) starting from the annually mean increasing rate of the population for the 2002-2007 period (fig. 6).

The results we obtained point out the fact that there will be a decreasing process of the population for the whole study area.

The communes nearby Hațeg town (Totești, Sântămăria-Orlea) will record a slight increase, by the migration of the population in the periurban area, whereas those far away (Densuș, Răchitova, Sarmizegetusa), which have no economic perspective and an inadequate infrastructure, will be characterized by a decreasing process of the population.

### 3.5. Suggestions and their geomorphologic consequences

After performing a morphologic, morphometric and morphologic analysis and relating relief with the population, the main actor of any planning and development strategy, we have to suggest the activities the relief is worth being used for. However, there are some restrictions that make the activity more difficult than previously imagined.

One of them is the large surface of the study area. For a territory of over 1.500 sq. km, it is impossible to make specific suggestions. That is why in the future, in case development studies are elaborated at administrative unit level, following detailed analysis, more specific suggestions could be made. Then, we have to start from the existing situation and suggest activities to turn to good account those relief aspects

that are neglected and that could lead to the future development of the rural communities.

Also, through the activities suggested, we aim to mitigate certain processes that destabilize the landforms.

Taking into consideration the analyzed morphologic, morphometric and morphodynamic aspects, most of the territory is *restrictive* to expanding built areas, practising agriculture or building transport and technical-edilitary infrastructure.

Thus, for *expanding the built areas*, the surfaces with low gradients (the threshold slope for building is 17° according to Goodie [0]) and fragmentation values and stable from the dynamic point of view, which overlap the floodplains and the accumulation piedmonts, are to be used.

Being subject to floods and overmoisturizing, protection and draining works have to be performed.

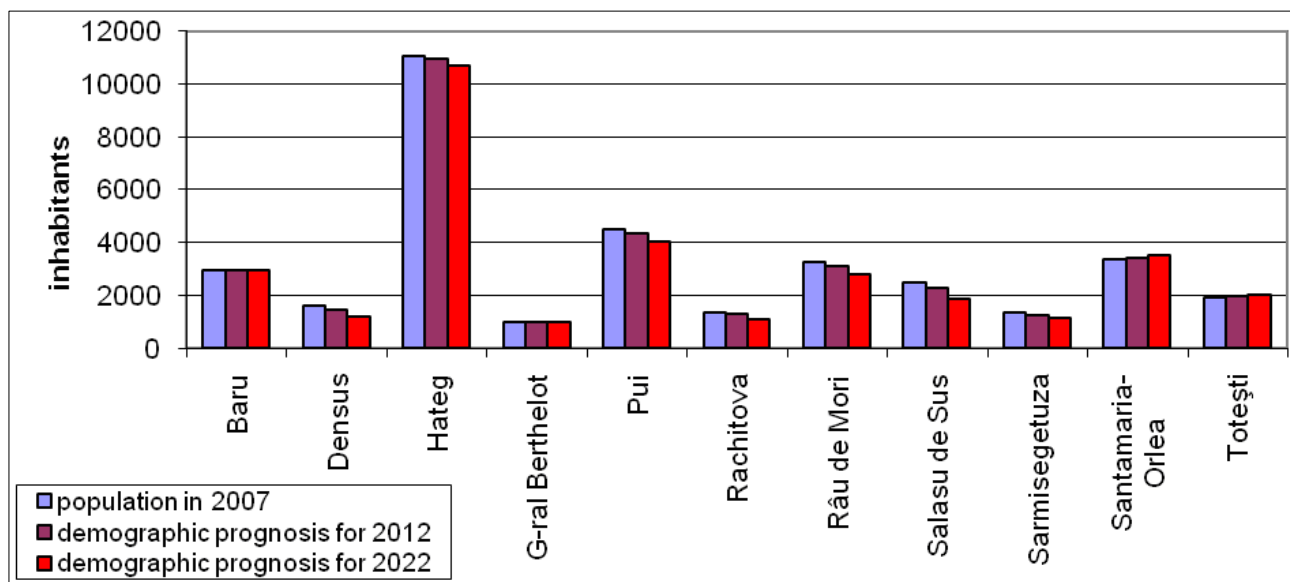


Fig. 6. Upper and middle sectors of the Strei valley. Demographic prognosis.

#### In agriculture:

- as *arable lands*: the areas with gradients of up to 12°, as this is the threshold slope of using farming machines [0] and low fragmentation that overlap the Galbena, Râu Mare and Strei floodplains as well as the interfluves that separate the Bărușor, Râu Bărbat, Paroș, Salas etc. in the low sector (fig. 6);

- for *fruit growing and viticulture*, the sunny slopes from the Fizești and Galbena catchments are favorable. We have to mention the fact that these slopes, highly susceptible to landslides occurrence, were planted during the communist period with fruit trees (especially plum trees) as a mitigation measure. But, after 1989 these processes were reactivated through land use conversions (orchards to arable lands or pastures) by the owners. Under these circumstances, we suggest stabilizing the slopes by recreating those fruit plantations;

- as *pastures*: the slopes with high elevations, gradients and fragmentation from the mountainous region.

The accumulation and erosion piedmonts from the Hațegului Depression, which consist of packages of rocks with different degrees of resistance to erosion, and which are characterized by high gradients and fragmentation values, should be used as *grasslands* or *forested areas*. The geologic, morphologic and morphometric aspects are preparatory causes for landslides occurrence and the triggering ones are the anthropogenic activities, among which overgrazing stands out as most of the landslides sites overlap the low productivity pastures (Sânpetru, Săcel (Sântămăria-Orlea commune), Baru, Livadia (Baru commune), Râu Bărbat, Ponor (Pui commune), G-ral Berthelot etc.) [0].

For *building and expanding transport infrastructure*, the landforms (floodplains, terraces,



interfluves), stable from the dynamic point of view, with low elevations, gradients and fragmentation, do not impose restrictions. The accumulation and erosion piedmonts from Hațegului Depression, with an active morphodynamics, high gradients and fragmentation values, are restrictive from this point of view. The mass movement processes (landslides, rock falls) triggered in Baru - Merișor sector endanger the traffic and the mitigation measures that were adopted seem to be inefficient.

As far as *tourism* is concerned, the study area allows practising different types of tourism (e.g. geological, scientific, recreational etc.) (fig. 6) as there are many natural monuments and reservations (gorges, peaks, fossil beds etc.) within the boundaries of the three important protected areas which overlap the upper and middle sectors of the Strei valley: *Retezat National Park*, *Grădiștea Muncelului-Cioclovina Natural Park* and *Hațegului Land Dinosaurs Geopark*.

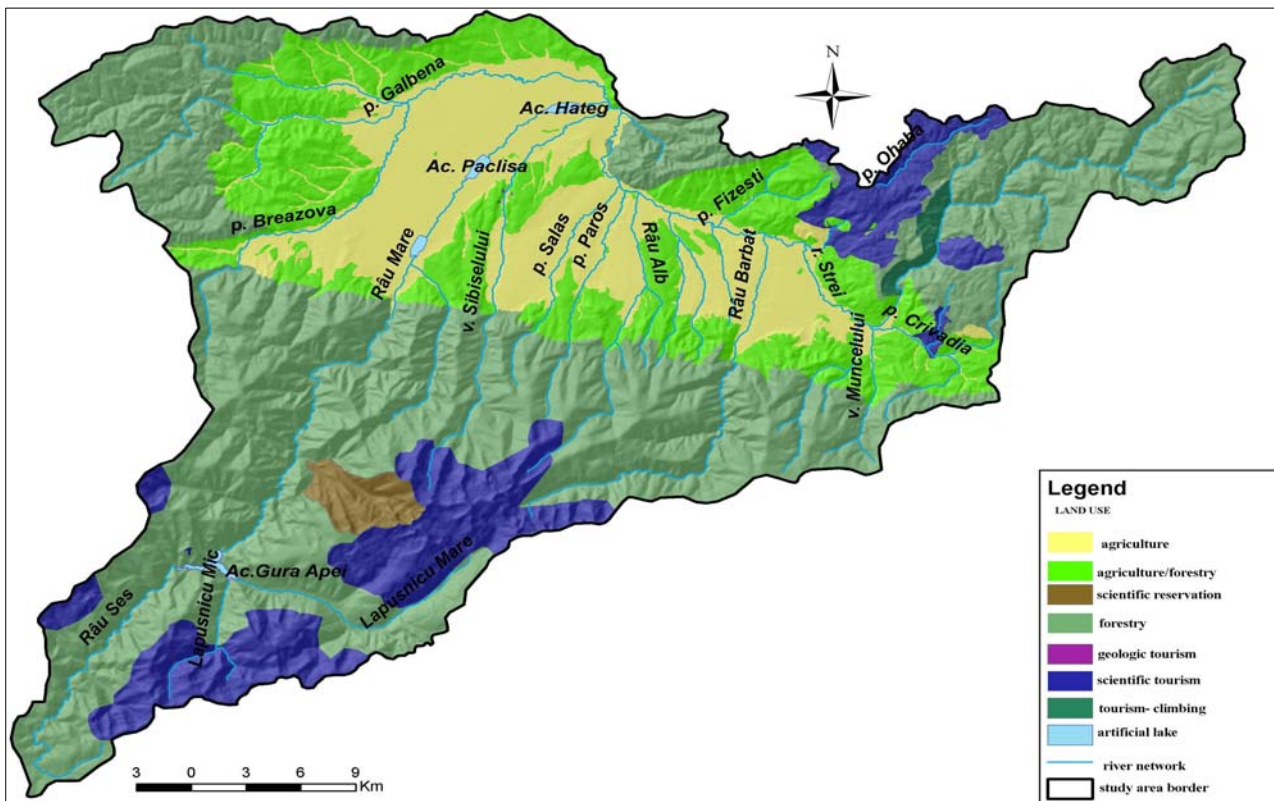


Fig. 6. Upper and middle sectors of the Strei valley. Suggestions.

#### 4. CONCLUSION

The relief has always been support for the development of rural communities in the upper and middle basin of the Strei valley.

The landforms with low elevations, gradients, fragmentation values and stable from the morphodynamic point of view, (floodplains, terraces and interfluves) have been used for building habitats, transport infrastructure and engineering works.

They offer accessibility and allow population mobility and the development of a variety of activities.

On the other hand, the areas with high gradients and fragmentation values and unstable from the morphodynamic point of view, have been avoided.

All these point out the fact that the population has properly assessed each site, using it according to the historical, cultural, economic, social and technological context.

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