

## THE IMPACT OF NATURAL HAZARDS OVER TOURISTIC VALORIFICATION OF GEOMORGOLOGICAL SITES FROM BUZĂU SUBCARPATHIANS

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**Abstract** – The geological and geomorphological structure of Buzăului Subcarpathians, a subunit of Curvature Subcarpathians, increases the apparition risk of natural hazards associated with distinct risk phenomena. The intensity, frequency and length result in a rapid modification of existent relief forms (morphography, morphometry and morphology) and the apparition of new ones, but also the accentuation of slope instability, with strong effects on road and touristic infrastructure. There are frequent processes that appear in this region, such as landslides, falls and mudflows that are associated with geomorphologic and hydrologic risks. The high vulnerability of geomorphological sites to geomorphologic and hydrologic hazards has a negative influence over the region's touristic activity. The decrease of tourist's number and of transport activities, accommodation and other services are determined by the difficult access to these geomorphological sites: sloppy roads, floods, sites isolation, but also by the absence of promotion programs, partial or total sites destruction, the impossibility of economical exploitation etc.

**Key words:** relief, geomorphological processes, vulnerability, tourism, risk.

### 1. Introduction

Buzăului Subcarpathians are located between Slănicului Valley – in east, Buzăului Valley and Romanian Plain – in south, Teleajen Valley and Cricov Valley – in west, and Ivănețu Hill – in north.

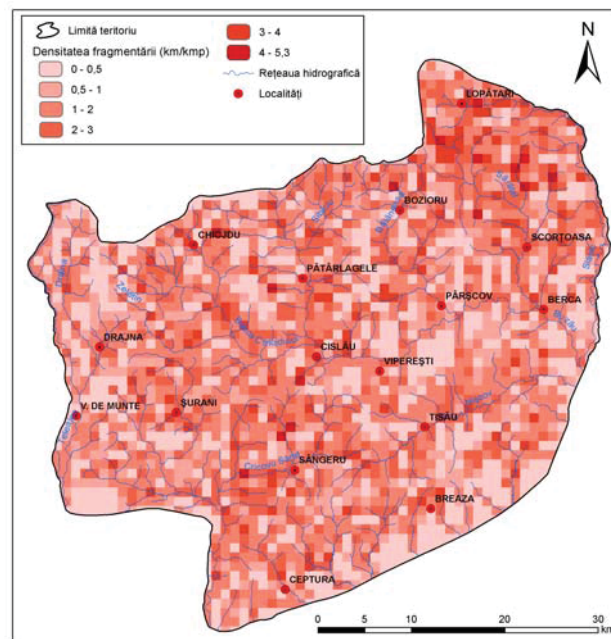
The region has a great structural and lithological complexity and it presents a morphology that has many relief conformities, like hilly crests over anticlines and subcarpathian depressions over syncline alignments, with a high rock and structures variety, from Paleogen flysch to Neogene molasse and Căndești pebbles.

The altitude varies between 825 m – Blidișel Peak, and the lowest point situated at the confluence between Bălăneasa Valley and Buzău Valley, which

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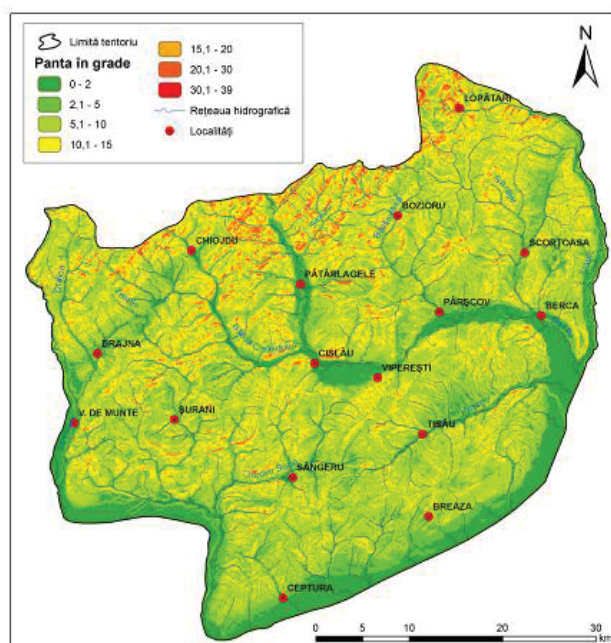
results in an average relief energy of 652 m. Relief's fragmentation density has a average value of 4 km/km<sup>2</sup>. Along the valleys appear the smallest values (2-3 km/km<sup>2</sup>) – meadows, terraces, alluvial fans. The highest values of 6 - 6.5 km/km<sup>2</sup> appear in south-west, on steep slopes from “Cândești pebbles” facies (Fig. 1).



**Fig. 1.** Buzăului Subcarpathians. Relief's fragmentation density map.

The declivity influences the actual Pleistocene geomorphological processes, emphasizing their intensity and frequency from Antropogene, once with the diversification of exploring and exploitation techniques of agricultural and forest space. The slopes vary between 1.5 - 45°. The value 1.5° appears on meadows, the values between 1.5 - 3° on terraces and alluvial fans. Values of 6 - 12° appear on active flanks with landslides and clay/shale rocks (Fig. 2).

The slopes with more of 12-24° that appear in the Buzău Subcarpathian sector contain alternations of marls, clays and gritstones. There terrains are usually used for orchards. Slopes of more than 25-36° belong to flysch area from the north side. The rocks that appear are mostly gritstones and gravel and sectors of pronounced slopes correspond to convex segments of slopes or steep deepening valley sectors. The slopes of 36-45° are abrupt, with detachment ravines and portions of cuestas affected by collapse and gulying processes. The slopes with more than 45° appear on abrupt river banks and on walls created by gravel and gritstones.



**Fig. 2.** Buzău Subcarpathians. Slope map.

In Buzău Subcarpathians appear three morphostructural subregions:

1) *Piedmont hills region developed on a Levantin – Quaternary monocline structure.* It completely contains an alternation on gravel and sands in the monocline structure. Because this is a piedmont it *presents* large accumulation structural surfaces, with alignments of cuestas orientated towards west, north-west and north.

2) *Hills and depressions corresponding to Pliocene structures.* They are characterized by simple and large folds, almost symmetric, with small falls. Some sectors present axial bulging and immersions.

3) *Hills and depressions region corresponding to Mio-Pliocene structures.* They appear on a large surface and are crossed by many symmetric and asymmetric anticlines and synclines, with transversal or longitudinal falls that are duplicated or cutoff on the direction north-east – south-west or east – west. Along these ones we find a system of tectonic lines along which there appear slight folds overlapping and twists.

After the folds direction and the tectonic degree, there appear two zone:

a) *The inner zone* with anticline hills, syncline hills, monocline structure hills, flank hills; hills developed on complex structures, syncline depressions; anticline depressions and large anticline valleys (wealds); flank and contact depressions developed on monocline structures.

*b) The external zone* with a close fold facies oriented west – east with a slow arching towards north-east in Istrița Massive region. It contains: anticline hills, complex structure hills, syncline depressions, anticline depressions and flank depressions or of lithological contact.

Geomorphological features of Buzău Subcarpathians mark the presence of a young region with an accentuated relief mobility reflected by the nowadays slope and river bed conformation and dynamic.

## 2. Natural hazards and associated risks from Buzău Subcarpathians

Buzău subcarpathian region is a tectonic active one which is demonstrated by the seismic activity or the frequent earthquakes.



**Fig. 3.** Joseni Landslide

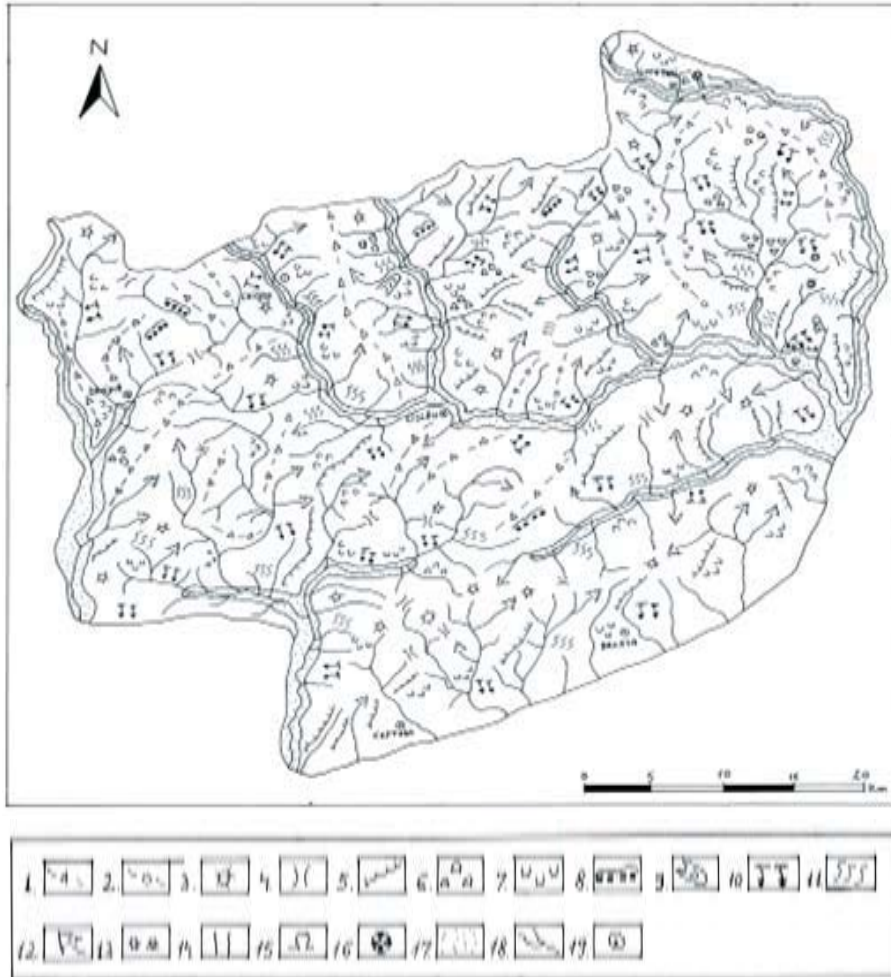
The intense morphodynamic of slopes and riverbeds (Fig. 3) shows region's high vulnerability to present geomorphologic processes, random evolution processes (hazards) with damages, life losses – risks.

Present slope shaping processes represent mass moving processes (mud flows, landslides, collapsing) and surface washing processes, rain wash and ravination. Beside these ones appear dissolution, suffusion and compaction

processes, and wind processes.

The risks associated with natural hazards from Buzău Subcarpathians materialize into territorial dysfunctions determined by seismic processes (geologic hazards), present geomorphologic processes (Fig. 4) (geomorphologic hazards), hydric processes (hydric hazards) and extreme climatic phenomena (climatic hazards).

**Geological hazards** determined by earthquakes because this are stands over an important Romanian seismic area (Vrancea area). It belongs to VIII seismic area (MSK zoning), with daily manifestations, under 3° Richter average earthquake intensity; telluric energy release cycles of high intensity (above 6.8° Richter) have almost 37-40 years. High intensity earthquakes appeared in November 10, 1940, March 4, 1977, August 8, 1986; lower intensity earthquakes,



**Fig. 4.** Present geomorphological process map from Buzău Subcarpathians

1. sharp interfluves
2. rounded interfluves
3. erosion – structural outlier
4. saddle
5. cuesta
6. deep landslides
7. superficial landslides
8. stones rolling
9. mud flows
10. surface washing
11. gullying
12. torrent
13. mud volcanoes
14. salt lapies
15. salt cave
16. salt valley
17. meadow
18. hydrographic network
19. localities.

of 4-5° Richter appeared on August 1894, May \1912, May 1991 and October 2009. *Seismic movements* from our area *triggered landslides, subsidence and collapses*. The most important earthquakes in the last 40 years, which caused damage or lead to changes in the landscape were: March 4, 1977 - 7.2 magnitudes on the Richter scale and, August 1986 - measuring 6.9 on the Richter scale and, in May 1991 - with a magnitude of 5.1° Richter. The effects of March 4, 1977 earthquake have resulted in modification of groundwater movement along fault lines, mud volcanoes reactivation in the settlements Tulburea, Ursoaia, Tega,

Lopătari and Pânătaului and Muscel basins, but also into a very high slopes mobility, particularly by landslides, subsidence and collapse.

**Geomorphologic hazards** are conditioned by relief's fragmentation, energy, exhibition and geodeclivity, the type and amount of precipitation, including their duration, the degree of seismic and lithology and deposits structure. It is a favorable area for such processes. The most common phenomena in the study area are related to mass movements and surface erosion by runoff and gullying. About 51% of the investigated territory surface is affected by mass processes, with a dominant role in slopes shaping. Linear erosion (runoff, gullying) appears on approximately 14.5% of the territory, an area in which these processes are associated with lenticular landslides and mudflows, frequent rockfalls and collapses.

Mudflow, sand flows and debris flows from Buzău Subcarpathians have the average length of 200-300 m and width between 38-40 m. They are accompanied by landslides, local landslides, erosion processes in depth. Pătârlagele Depression presents 34 of such flows, best known are those of Chirleşti, Blădişel, Pânătau, Cuculeşti, Malul Alb.



**Fig. 5.** Lapoş Valley Landslide

Pseudo solifluction processes include slow soil flows over the frozen substrate. They are an important factor into shaping slopes developed on clay and marl, creating a wavy micro relief.

Landslides have a large share in relief shaping. About 51% of Buzău Subcarpathians surface is affected by these geomorphological

processes. There are frequent medium and deep landslides, with sliding bed depth between 3-12 m, but does not lack the shallow landslides, of furrow or lenticular type. They cause significant damage by destroying homes, roads, crops of fruit trees, farmland and forests (Figure 5).

Subsidence, collapse and stones rolling processes are closely related to the presence of folded, faulted faults, hogbaks relief, steep slopes, loose lithology with poorly consolidated deposits on which exerts its seismic shocks, alternating freeze-thaw action, erosion and undercutting river activity and anthropogenic activities. They are spread on slopes with gradients between 60 and 70° and with degraded steppe grassland vegetation represented by *Nardus stricta* (prickly), abandoned orchards or forest glades (Colţi, Goideşti, Lopătari).



**Fig. 6.** Gully processes inside the perimeter of Pâcelele Mici mud volcanoes.

Runoff and gully processes have an important magnitude into Buzău Subcarpathians space, because of climate change and intensification of subsoil and landscape resources exploitation (Fig. 6). The formation of torrential bodies in the space of Buzău Subcarpathians is stimulated by returning to traditional agricultural practices, overgrazing and abandoning the agricultural terraces and hence trees – vine crops.

Hydrological hazards recorded between 1968 and 1976 confirms five periods of rainfall that had strong effects on terrain modeling. Four of them (June-July 1969, July-August 1970, May-July 1971, July 1975) were characterized by intense rainfall of maximum 177.8 mm reached within 24 h. This led to the onset or reactivation of geomorphological processes (landslides), but also to catastrophic floods - 1969, 1971, 1975, which caused significant damage and casualties.

Climate hazards are recorded by severe droughts, especially in the south and southeast region of Buzău Subcarpathians. They are common in hot summer days, with thunderstorms and hail phenomena accompanying heavy rains.

### **3. Negative effects of natural hazards over touristic activities**

The negative effects are induced by the Subcarpathian Buzău space's vulnerability to geological, geomorphological, hydrological and climate hazards manifestation, with the combination of specific risks, especially to induce landscape disfunctions with redundant effects in tourism activities. Summarized, these effects are:

- lack or impossibility of building a modern road infrastructure; in this area the vast majority of roads are paved, and where there may be asphalt appears a noticeable degradation. Landslides, torrential rains, subsidence make yet almost impossible maintaining roads in relatively good condition;
- higher costs related to the construction of technical infrastructure, than in areas where topography presents fewer vulnerabilities;
- higher costs in the construction and arrangement of quality tourist facilities and a modern recreation;

- the existence of additional costs done to ensure the safety of tourists, as long as they are in the region;
- the deterioration of touristic markings, of infrastructure elements that protect roads, buildings, bridges and culverts etc.;
- additional costs of land reclamation works in areas affected by disasters or those with a high risk of producing unpleasant events;
- additional costs for tourists by introducing in price the cost of supplying determined by difficult supplying or those caused by various additional safeguards.
- reducing the number of tourists in the area due to difficult access or inability to use the own cars.

Focus human and material efforts in reducing vulnerabilities of Buzău Subcarpathian space would lead to increased tourists number and consequently to rapid and efficient development of tourism activities.

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