DOI: 10.29302/Pangeea 18.14

EVALUATION OF NATURAL POTENTIAL AND VULNERABILITY OF TERRITORY TO RISKS. Case Study: SÂNTIMBRU COMMUNE, ALBA COUNTY

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ABSTRACT: *In a world in constant chaotic development, a study focused on a well established territory, with a detailed description of the existing situation and a correct analysis of the vulnerabilities resulting from the interactions between the natural and the antropic component, with emphasis on providing solutions for restoring optimal functionality is imperative. This study seeks to identify, on the basis of a detailed analysis of the specificity elements, the inadequacies that arise from interactions between the natural environment and its anthropic use, and propose remedies and optimization of territorial functionality on medium and long term.*

Keywords: *natural potential, risk processes, vulnerability, GIS, raster interpolation.*

1. Introduction

Studies to determine the degree of vulnerability of a territory to risks require a detailed analysis of the natural potential, together with the other components of a geographic system. Although such studies occur frequently, the problem arises at the level of generalization at which they are achieved and in the absence of thorough grounding. The present study is welcomed by the degree of detail in which it is realized, the scientific approach being centered on a single territorial administrative unit, namely Sântimbru, increasing the chances of surprise the territorial reality.

Sântimbru commune is located in the central-western part of Romania, in the central area of Alba County, at the westernmost end of the Transylvania Plateau, in the Alba Iulia-Turda depression corridor and runs on both sides of the Mure River course. From the administrative point of view, Sintimbru commune is neighboring Mihalţ (northeast), Teiuş (north), Galda de Jos (northwest), Ighiu (west), Alba Iulia (southwest), Ciugud (south) and Berghin (southeast). The commune, as an administrative unit, consists of five villages: Sântimbru, the commune's residence, located approximately in the center of the commune, at relatively remote distances from the localities on the right bank of the Mure River subordinate (Galtiu at 1,0 km, Coşlariu at 3 , 0 km) and relatively larger distances to settlements on the left bank of the river: Totoi to 4.0 km and Dumitra to 6.0 km. According to data obtained from PATZ Valea Mure ului, Alba County (2011), the total area of the commune is 4428 ha [5].

2. Materials and methods

The creation of the database was accomplished by: vectoring of some geographic details (level curves, rivers, access ways, intravilan), analyzing old or current cartographic materials, collecting statistical data from specialized institutions, accessing public databases , consultation of

specialized literature. Field investigation and validation of some of the situation in the study area was completed by field documentation.

The analysis of the natural potential of Sântimbru commune was achieved through the punctual approach of some elements such as morphological potential and geological substratum, the potential of the hydro-climatic component, the potential of the biopedosphere fund and the natural heritage. There were plans for each type of analysis at the level of the components of the Sântimbru territorial system, using the GIS technology, followed by a thorough local analysis or synthesis at a general level.

To determine the vulnerability of the territory to risk processes, the GIS-Raster Interpolation IDW function was used, in which the hierarchy was established by dividing the analyzed area into 1-square-meter grids and assigning scores from 1 to 5, the score 1 signifying risk low to nonexistent, and maximum 5 risk. The scores awarded are the result of the summation of points awarded to all types of critical processes / states / dysfunctions identified in the territory.

The analysis of the degree of suitability of the building relief (raster analysis) was done using the GIS Map Algebra function. With mathematical operators of "gathering" and "multiplying", mathematical operations were applied to raster images, resulting in two maps in which the degree of suitability of the building's relief is pointed out differently.

3. Results and discussions

3.1.Analysis of the natural potential of the territory

3.1.1. Morphological Potential and Geological Substrate. Seated at the interference of distinct physico-geographic units, the Apuseni Mountains and the Transylvanian Depression and modeled by the main hydrographic artery - Mure River, the investigated space is in the form of a contact depression on the axis of a large synclinal parallel to the western mountain area, guarded by zones the higher geomorphological features, the Bilag Hill to the west and the Secaşelor Plateau to the east, including the meadow and the terraces of Mure River [3] (fig. 1).

The morphological level of the plateau, present in the northwestern part of the commune, consists of the Secaşelor Plateau, the lowest morphological unit of the Plateau Târnavelor (300-500 m), has the appearance of a suspended platter with a slightly wavy surface on the territory of the village Dumitra and partly to Totoi, the maximum altitude reached in Gurguleu Peak - 418.8 m [3].

Bilag Hill is an anticline shaft, resulting from a recent effort to exalt the Southern Apusians, which coached the Southwest corner of the Transylvanian Depression on the Sard-Oiejdea-Blaj line in a quest and lifting movement. It is the highest morphological unit in the region, with an altitude of 431m in the Sântimbru Peak [5].

The Mure River meadow occupies the largest area of the analyzed area (Coşlariu and Galtiu villages, and some of Sântimbru and Totoi villages), developing on both banks of the Mure River River, with maximum extension in the Galtiu area. Of the eight terraces of the Mure identified on the territory of the commune, the terrace I (3-6 m relative altitude and 225-230 m absolute altitude) is distinguished and the second terrace (8-12 m, relative altitude and 230-240 m absolute altitude), both pleistocene age [1] (fig. 2).

Regarding the geological aspects, Sântimbru commune is located in the south - eastern marginal part of Transylvanian Depression, in the sub - mountainous area, where, from the point of view of the structural relief, the strata are cut, having in the middle a salt kernel. Rocks are generally formed from soft, weakly consolidated rocks, lacking the harsh rocks horizons [2].

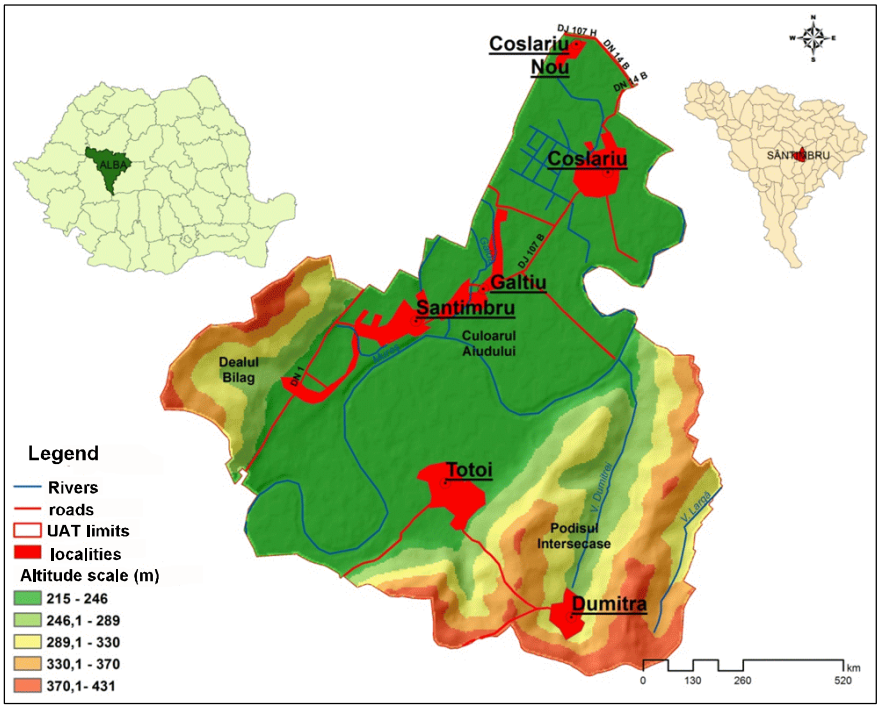

Fig.1. Geographical location of Sântimbru commune

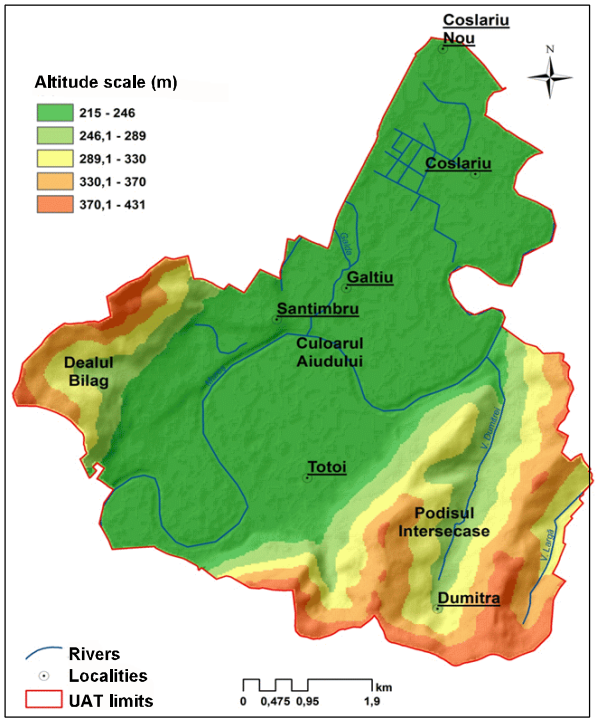

Fig.2 Hypsometry and morphological units of Sântimbru commune

In the basement of this area there are sedimentary neogenetic rocks (Acvitanian-Badenian-Sarmatian), represented by red and gray clays, marls, sands (often alternating with clays) and gravel [1]. Badenian age volcanoes are located in the village of Totoi. Frequently, they are transformed, forming bentonites, present in a large area on the left bank of Mure River. The most recent deposits are those of quaternary age, present in the areas of meadows and terraces, made of sand and gravel.

On the eastern slope of Bilag Hill, located between Bărăbanţ and Sântimbru Fabrică, there are rock formations of the Aquitaine age (about 23 million years old), made up of clays, sands, majestic clays, with a layer of Ostra remnants, the presence of these shells suggesting that at that time the area was covered by the sea. Over the Ostra bench there are newer formations consisting of gravels and conglomerates [2] (fig. 3).

3.1.2. Potential of the hydro-climatic component. The territory of the commune is situated in the moderate continental climate of hills and low plateaus, with obvious foehn phenomena. The circulation of western and western masses of western (wetter and warmer) masses favored by the Mure River corridor and the "presence" in the vicinity of the Trascău Mountains determines the presence of the foehnization phenomenon . To this is added the north-northern eastern part of the air masses, which causes the air to cool in winter [7].

The average annual temperature is 10 ° C, with minimum in January (-2.7 ° C) and maximum in July (average + 20.7 ° C). Atmospheric precipitations are slightly deficient, with an annual average of 537 mm. The maximum rainfall period is recorded between May-June and July (155.5 mm average) and the minimum period in February (a little over 21 mm). In winter, snow falls on average in 22-28 days and

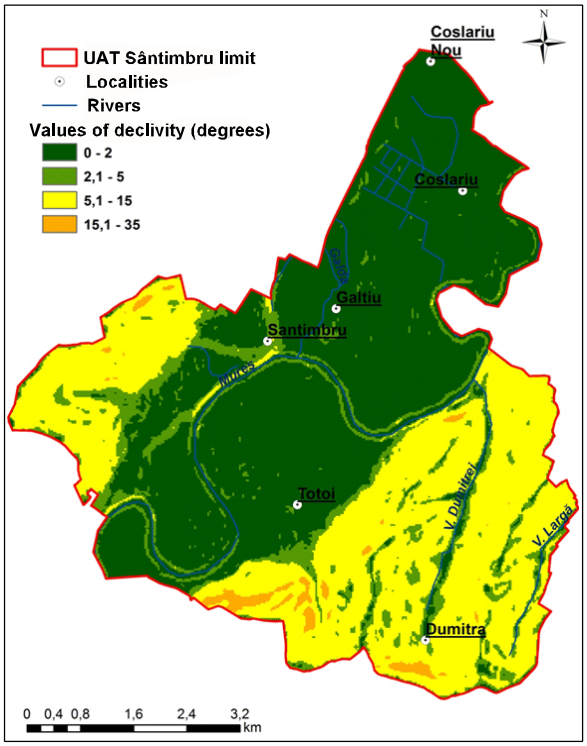

Fig.3 Declivity map of Sântimbru commune

results in the deposition of a layer of snow with an average thickness of 4-7 cm but which can reach 30-40 cm (especially outside the localities). The snow layer is kept on the ground for an average of 35-45 days. The fog phenomenon , often in spring and autumn in this area , can accentuate and prolong the cold (days with very low temperatures) [7].

Groundwater. In this region, local or discontinuous aquifers are cantonized in the gravels and sands of the Mure River corridor and its terraces, with important underground water reserves. The Sântimbru locality is part of the underground watersheds in porous rocks. In the lower meadow, the underground is at a depth of 1 to 4 meters, while in the terrace area it is at a depth of 4-6 m in the terrace area I and 8-10 m in terrace area II. Ground water supply occurs from several sources: directly from rainfall, surface runoff or river infiltration. Drainage in general is a good one missing the ponding phenomenon . During the melting season they reach maximum levels; in the summer, however, during drier periods, the groundwater level has the lowest values [6] (fig. 4).

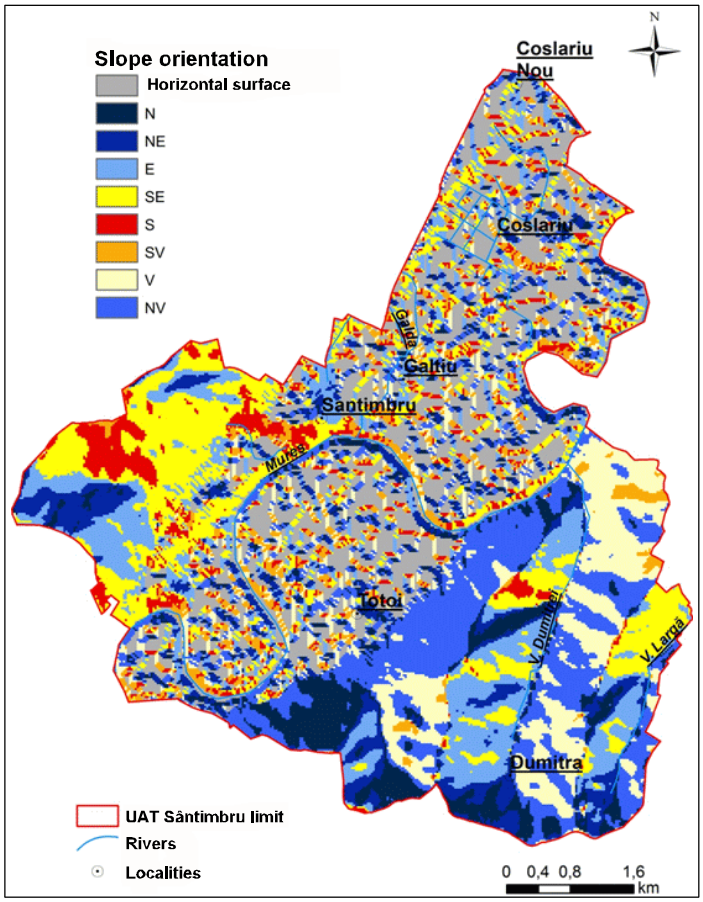

Fig.4. Slope orientation map

Surface waters. The main watercourse is Mure River, which crosses the commune's territory about 10 km in the NE-SV direction, at an altitude of 220 m. Between Coşlariu and Sântimbru, the valley of Mure River is wide, forming a real basin with a

maximum extension of and between Sintram and Bărăbanț narrows due to the Bilag Hill and the Secașelor Plateau. The meadow presents a special morphology with meanders and rings. The average multi-annual flow rate is 110m³ / s. The greatest volume of leakage is at the end of winter and early spring. Maximum flows are in April, May, June (178m³ / s, 109 m³ / s, 114m³ / s), and the lowest in July, August and September (48.8 m³ / s, 27.9 m³ / 27,2m³ / s). The main tributaries of Mure River are: Tarnava and Galda. Creeks, some with temporary leaks and small torrents from the hills are very active during heavy rains [7].

3.1.3. Potential of the biopedosphere fund. Relief and nuance of climate exaggeration is reflected directly in the vegetation and soil composition (fig. 5).

The most frequently encountered *soils* are frequently alluvial, frequently gleyed, with a varied texture, being related to the existence of the Mure River meadow, which is located on most of the commune. Erodisols and / or regosols with lutearic texture appear mainly on slopes subject to accelerated erosion or landslides being spread on the left bank of Mure River, in the area of Totoi and Dumitra villages. Gleic soils and lacquers have a varied texture being formed and evolved in the conditions of the occurrence of an excess, periodically or permanently, of water from the groundwater, atmospheric precipitation, etc. Typical argilo-clay chernozems, with luteargous texture, appear in the hilly area of Totoi and Dumitra. Here we can also find the Cambian soils: typical Eumezobasic browns and eroded Eumosobase brown soils. Pseudoradins, argiloiluvian pseudorazines are common in Secașelorelor Plateau, formed on loose rocks containing carbonates and clay, respectively on marl or clayey marl [2].

The vegetation is specific to hilly and meadow hills, being influenced by climate and relief. In the meadow area, the flora is rich and varied, being represented by herbaceous plants, such as: grass of the field, fir, pylorus, rogos, various clover and alfalfa species. The arboreal species encountered are the willow, wicker, poplar and shrubs. The vegetation in the hilly area is made up of tree species, of which we recall oak, maple, hornbeam, juniper, ash, lime tree, alongside which can be found acacia, wild apple, poplar and some species of shrubs such as: woody dog, porumbar, horn, hazel, worm, mary and others. The forest vegetation meets on the hills around the villages of Dumitra and Totoi, and the other villages are missing, with various shrubs being encountered here. In grazed areas, unoccupied by permanent crops, we encounter the vegetation specific to pastures and meadows: fescue, beard and other sporadic forms. On the slopes we encounter wormwood, poppy, crow onion, colilia, alfalfa, cornflowers etc. [2].

The specific fauna is that of the silty steppe biotype, in which the rabbit, ferret, weasel, fox, predominate, alongside which we meet the goat, the squirrel, the wolf and the wild boar. The world of birds is represented by knockers, whippers, gouache, cuckoo, henchmen , quail, pheasant, etc. On the cultivated lands we meet the the seaman's crow, the lark and the blackbird. Among the reptiles we mention , common lizard, different species of amphibians, a lot of insects and gastropods specific to these relief forms. The waters of Mure River belong to the area of the scobar, besides which there are also the clean, the morun, the pike, the carp, the shawl, etc. Some of these fish also live in the water of the Galda Valley [5] (Fig. 5).

3.1.4 Natural Heritage. In Sântimbru commune there are no official monuments belonging to the natural heritage. Its natural landscape is not spectacular, but surely for the locals it is a pleasant, safe, quiet habitat space like no other. Biodiversity is present in the territory both in the form of numerous fauna species and the diverse flora, particularly beautiful and diversified.

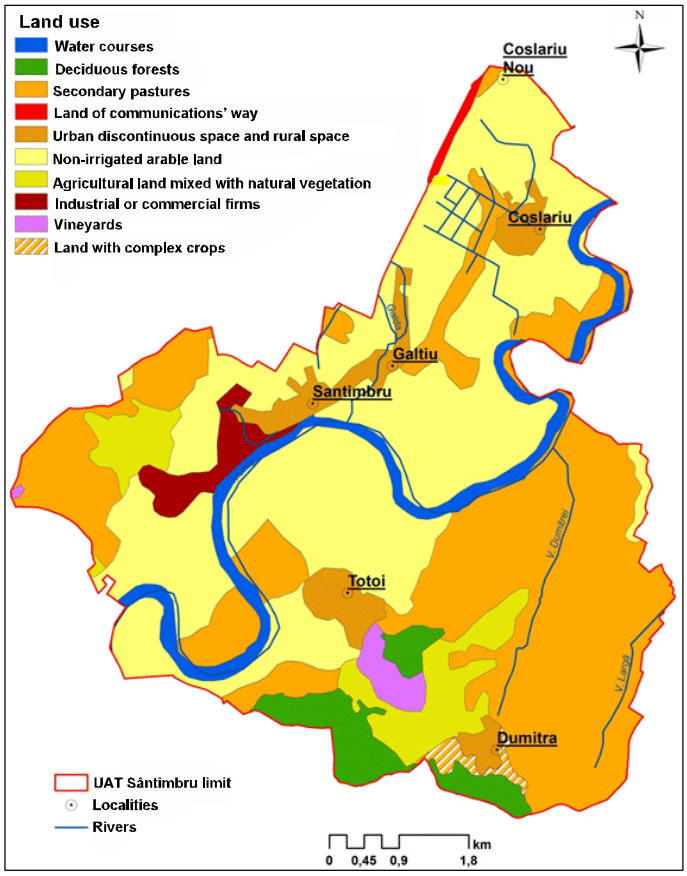

Fig.5. Land Use Map (Source: CLC 2014)

So we can find meadow flora, hilly area vegetation, forest vegetation and grassland and meadow-specific vegetation developed in deforested areas. Fauna species are also present in a varied form, from birds, to reptiles and aquatic species. The diversity of the landscape consists of three categories of natural landscapes: meadow landscapes, terraced landscapes, and hill and plateau landscapes.

Meadow landscape is spectacular due to sinuous flow of the Mure River, the meanders and the rings formed by the "moodiness" of the river, which from time to time decides to get out of the stern, flood nearby land and change thus the morphology of the meadow, in an attempt to avoid monotony . The Agroterassas on the Bilag Hill are also a palimpsestic landscape, a melancholic memory of the former occupations of Sântimbru. All these elements of nature must be protected by the balanced use of territory and the environment and the preservation of spaces with biological and landscape diversity [4].

3.2. Evaluation of territorial vulnerability in risk processes

3.2.1. Highlighting process-generating factors and risk phenomena. The lithological constitution (mostly formed of clay), the degree of vegetation coverage, the climate, the predominantly Nordic exhibition, but especially the quantity and the regime of the precipitations have led to

the formation of slope processes such as landslides and drainage. The lithological structure is characterized by rocks in general soft, weakly consolidated, lacking horizons of hard rocks near the surface of the land, which generated the lack of structural relief forms and determined the formation of the domed relief. The deforestation of the forest areas in the eastern part of the commune, namely in Totoi and Dumitra, generated important risk processes and phenomena.

Bilag Hill presents a geological structure consisting of an alternative mix of marl and sands, grubbed-up areas of the forest on the eastern side, heavy rainfall at some times of the year, generally high land slopes (over 10 °), northern predominant exhibition, excessive grazing. All these elements are factors generating processes and risk phenomena such as landslides and erosion processes such as deep erosion, sometimes with a very advanced evolution.

The north-western extremity of the Interseca elor Plateau, Coasta Mare Hill - Westside slope and Scaun Hill- western slope to the Mure River River is affected, on the background of the intensive pasture, of the slope with a value greater than 10 ° and the anthropogenic intervention of erosion and landslides, some of them still active and others fixed.

The Mure River slopes near Sântimbru and the left of the Gruiu valley show frequent slope processes, one example being the drainage due to the petrographic structure, the gradient, the degree of vegetation cover, the climate elements, but especially the quantity and the precipitation regime.

In the lower course, both mountainsides of the Dumitra Valley are affected by landslides and shore erosion. The deforestations, the lithological structure formed predominantly from the clays, the degree of vegetation coverage, the quantity and the regime of the precipitations determined the phenomena of torreness in the Largă Valley and the Dumitra Valley, on their upper course.

Among the meadow processes, the accumulation of washed and transported materials on the mountainsides takes place at all times, but with a different extent. The heavy rainfall from the maximum rainfall period from May to June (155.5 mm) contributes to the generation of risk phenomena and processes, amplifying the processes of washing materials on the mountainsides (erosion processes) as well as fluvial accumulation and transport and the Mure River River is very meandering downstream of Sântimbru. Of the processes in the minor bed, the most important is the meandering, the Muret has wide meanders, evolved in the form of "M". In the minor bed there are well-formed formations in form of sandbanks.

The low relief energy, the small difference between the meadow and the terraces of Mure River, the unconsolidated banks, the climate, the quantity and the precipitation regime caused the Mure River floods from 1857, 1875, 1887, 1893, 1933, the great floods of 1970, frequent after 1990, affecting the shores as the households in Galtiu and Coşlariu, and on the left bank the meadow between Sintimbru and Totoi. At present, the Mure River River is digging at the 10% probability of overtaking and the Galda River has been deepened and the banks strengthened [6].

3.2.2. Identification of dysfunctions induced by natural and anthropogenic processes. Natural and anthropogenic causes have led to some changes and transformations in the landscape structure. Bilag Hill, Scaun Hill, and the Coasta Mare Hill have experienced irreversible geomorphological changes: the destruction of the slopes, the deterioration of the soil cover and the petrographic layer, the destruction of the grazing areas so that we can say that it will never be used to the real value in the agricultural activities undertaken on its

surface, not to mention its suitability for construction.

Climate change in recent years worldwide has changed the climate's normal values, sometimes the extreme weather, from prolonged droughts, to sudden cooling in the summer, winds and hail, autumn fog or direct summer breaks to winter.

Negative transformations in the landscape structure also occur in Mure River meadow, which presents a special morphology with meanders and rings, a morphology that is in permanent transformation, the course of Mure River being strongly diverted to the left, flowing at the base of hills belonging to the Inter-Secaşelor Plateau, in especially due to sediment from the valley of Galda. The underground waters have a high hardness and the water quality is doubtful, being influenced by the economic units on the territory of the commune (which discharge toxic residues) or those located in the Mure corridor.

Contamination of groundwater or surface water with substances that have a negative effect on the organism, such as nitrites, nitrates, pesticides etc., is a current problem in Sântimbru commune, where the quality of the water collected from the wells and the water courses is analyzed periodically.

Pollution of Mure River with industrial waste from Ocna Mure River and Târgu Mure has led to a dramatic decline in fish fauna in recent decades [7].

3.2.3. Zoning of the territory according to the typology and the impact of the risky processes. After detailed analysis of cartographic materials (maps and topographical plans at the scale of representation 1: 25,000 and 1: 5,000, orthophotoplans, etc.), as well as field investigations, we have reached the following zoning of the territory according to typology and impact risking processes:

Non-existent risks areas include high-stability areas in terace II of Mure river, on its right and in the northwest of Sântimbru locality. We fully find the intravilan locality of Coşlariu, Galtiu and partly Sântimbru. An area of great stability is also located on the left side of the Mure River, in its terrace I, near Totoi.

Low-risk areas are dispersed within the investigated territory and cover largely the Mure River meadow and terraces, the north slope of the Bilag Hill, as well as portions from the Secaşelor Plateau, in the interfluvial valleys of Dumitra, Largă and the elevated interfluvial peaks from the Coasta Mare Hill and Scaun Hill.

The medium-risk areas include the terraces I and II of the Mure River, the domed slopes of the Bilag Hill and the plateaux from the Secaşelor Plateau.

The High-risk areas include smooth land with a slight slope at the base of the Bilag Hill, Coasta Mare Hill, Gruiului Hill and Scaun Hill.

The very high-risk areas include most of the south-eastern slopes of the Bilag Hill, the north-west slope of the Coasta Mare Hill, located on Secaşelor Plateau, to the east of Totoi and the north of Dumitra and the western slope of the Scaun Hill (to the Mure River), situated at the eastern extremity of Sântimbru commune, with low stability induced by high values of the slope (15-23 °) and very active morpodynamics subordinated to the mass movement and overexploitation in an overgrown agricultural system. Very high risk areas exist in the southern part of Dumitra, such as the north-eastern slope of Gruiul Hill and the Gruiul valley, against the backdrop of elevated slopes (over 20°), petrographic vegetation, vegetation cover, and lithology rich in clays (fig. 6).

3.2.4 Building Reliability Analysis (raster analysis). The analysis of the degree for suitability of the building relief (raster analysis) was done using the GIS Map Algebra function. With this we can perform analyzes based on mathematical operations applied to raster images. Using mathematical

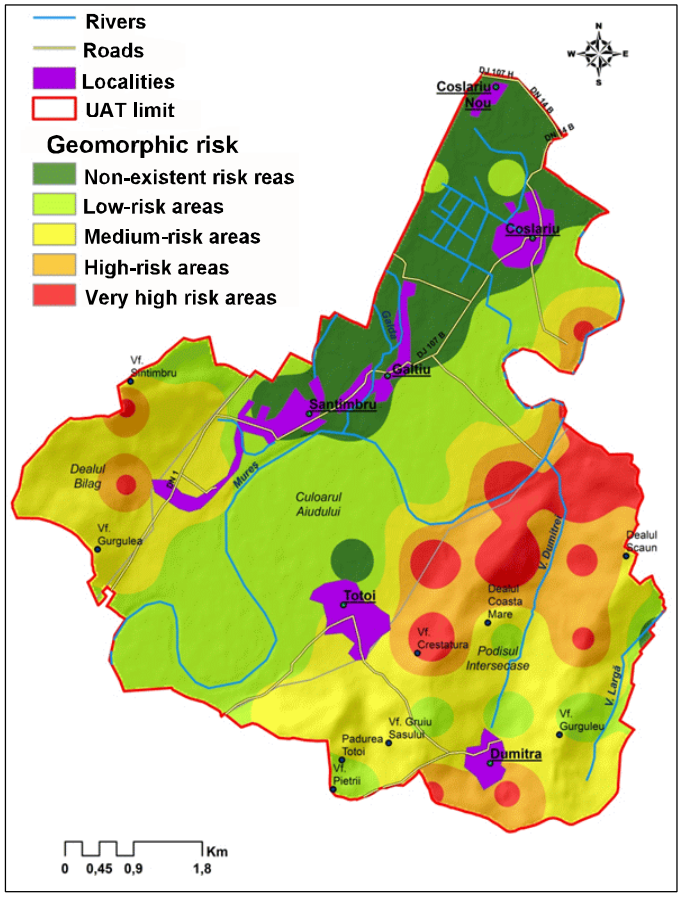

Fig.6. Territory vulnerability risk map

operators of "gathering" and "multiplying", there were 2 maps in which the degree of suitability of the building's relief is different.

The map obtained by the method of gathering the raster images (Fig.7) has an optimistic result, the favorable areas being represented by the meadow and the two terraces of Mure River and as the altitude and slope of the relief increases, the degree of favorability in construction decreases. Optimism results from the fact that the unfavorable degree is encountered only at the highest peaks in the investigated area, namely Sântimbru Peak from Bilag Hill, Gurguleu Peak from Secașelor Plateau, Coasta Mare Hill, Crestătura Peak, Scaun Hill, Totoi Forest, in their lower areas up to the Aiud Corridor, there are areas with poorly favorable and medium degree. The terraces and the meadows in the Aiud Corridor consist of favorable and very favorable areas for construction. According to this map, the probability of building the investigated space is quite favorable.

Regarding the map obtained by the method of multiplying raster images (see Figure 8), it presents a much more pessimistic version of the degree of suitability to build: InterSecașelor Plateau and Bilag Hill are considered to be totally unfavorable to the construction, including the Aiud Corridor and portions from Mure River medow (justified by the existing flood potential, without taking into account the existing built ditch, dimensioned to the 10% probability of overtaking) as well as the

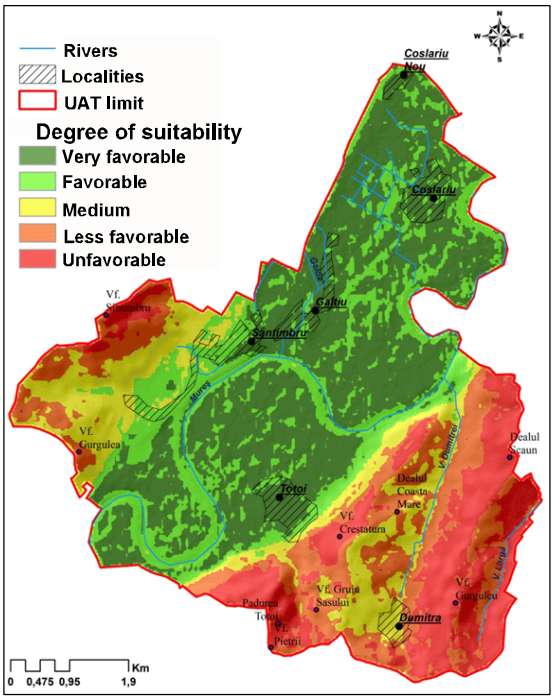

Fig.7 Map of the territory's suitability for construction - method of gathering

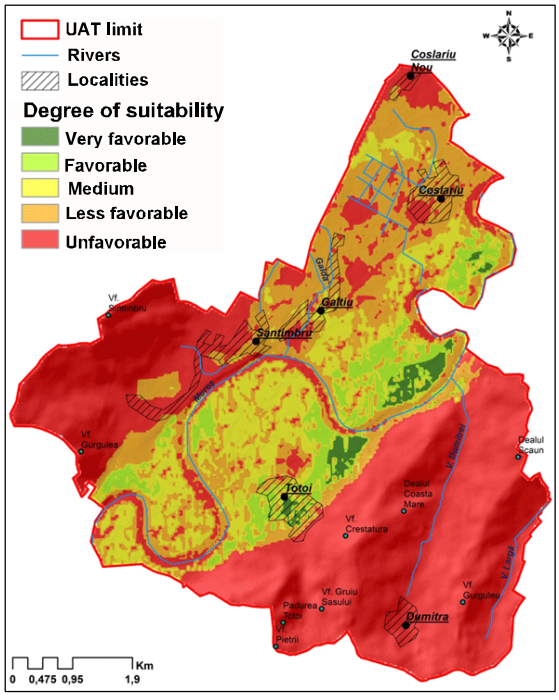

Fig.8 Map of the territory's suitability for construction - method of multiplying

Coşlariu locality, where in the past, before the construction of the canals, there were marshy areas. Favorable areas occupy a very small percentage and meet as stains in the Mure River terraces. According to the analysis of the map resulting from the multiplication of the rasters, the degree of construction affordability of the investigated territory is quite low, with only a third of the territory being amenable.

Conclusions

Contemporary geomorphological processes existing in the Sântimbru commune, especially the slope processes, can be considered critical. Thus, the impossibility of the system to return to its initial form after the intervention of the disturbing element, as well as a low degree of affordability in construction and agriculture. Therefore, due to landslides and erosion of the slope, the critical state, already established and obvious, is in reverse proportionality to the degree of territorial suitability.

The good part is that, once the risk factors are known, measures can be taken to prevent or attenuate the effects of these phenomena, but their stamp will persist in time and space, the effects being irreversible.

It is a pity that the lands affected by various dysfunctions and risk processes can not be used at maximum capacity, which affects the economy of the commune, which, in the absence of resources of tourist attractiveness, has to rely on agricultural activities

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