THE PROBABILITY OF LANDSLIDES IN THE TERRITORIAL ADMINISTRATIVE UNIT OF CUZDRIOARA

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ABSTRACT. **The Probability of Landslides in the Territorial Administrative Unit of Cuzdrioara**. The location of the Cuzdrioara Territorial Administrative Unit in the northern part of the Transylvanian Basin, at the meeting position of the Someșan Plateau and the Someșului Mare Corridor, indicates the existence of a fluvial relief. It is characterized by the presence of an alternation of valley passes and interfluvial passes, between which the connection is made through slopes. Their presence, to which are added the particularities of the geological substratum and land use, indicates the existence of some surfaces susceptible to landslides. To identify them, GIS techniques were used, which implied processing the existing information to obtain the map of landslide probability. It will be one of the necessary tools for the management of the hazardous phenomena created by landslides. At the same time, the information obtained can be used by decision-makers in the current and future urban planning actions.

Keywords: landslide, probability, urban planning

1. INTRODUCTION

The Cuzdrioara territorial administrative unit is in the northern part of the Transylvanian Basin. Territorially, as the localization map shows (fig. 1), it covers the following morpho structural units: the Someșan Plateau and Someșului Mare Corridor (Pop, 2001; Roșian, 2020). Administratively, it belongs to Cluj County, within which it has the rank of commune. It consists of three villages: Cuzdrioara (commune center), Mănășturel and Valea Gârbăului. From the last census, there are 3,093 inhabitants grouped in 937 households. The territorial administrative unit has a surface of 2474 ha.

The susceptibility to geomorphological processes, such as landslides, is related to the existence of a fluvial relief characterized by an alternation of valley passes and interfluvial areas, between which the connection is made generally

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through inclined surfaces, which sometimes are steep slopes. Along with the area's relief, there are other favorable factors to landslides, like the geological substratum and the land use.

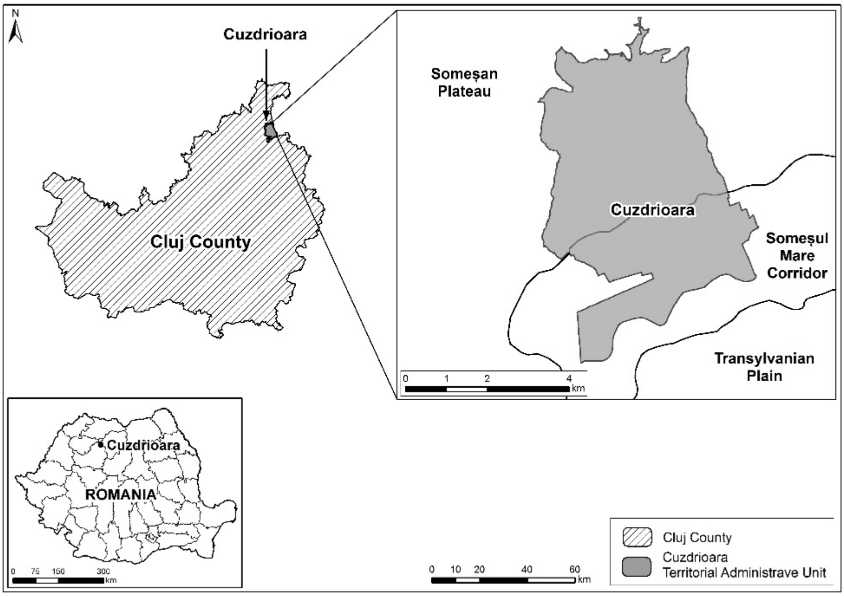

Fig. 1. Study area (Cuzdioara commune) localization map

All of these support the idea that the landform is a basically essential part of the environment and, simultaneously, it is the support of other natural components and other human activities. For this reason, it is crucial to understand the landform's importance for the development of territorial planning and urban development programs.

2. MATERIALS AND METHODS

To understand the probability of landslides, in the first stage, a database was created, a landslide inventory of the area, starting from the current information based on various cartographic documents and remote sensing images, to which are added the observations in the field. The creation and interpretation of the database were done using GIS techniques.

To obtain the landslide probability map, the methodology described in the national guide GT-019-98 (Guide for creating risk maps for landslides to ensure building stability) was used.

The application of this methodology meant overlapping several thematic layers, which contained the necessary information on the landslide probability.

The guide lists the following components: lithology, altitude, parameters of the relief (slope, fragmentation depth, fragmentation density), distance to rivers, current active geomorphological processes, land use types etc.

After the database was created, the values of each layer were further assessed based on their creditworthiness, according to the existing methodological norms and the particularities of the studied territory to get the susceptibility indices to geomorphological processes, based on which we finally establish the classes of landslides probability (Dhakal et al., 2000; Bălteanu et al., 2010).

This type of assessment is possible because the data are in raster format, and all operations are taking place at the pixel level, with a pixel resolution of 100 m, allowing to determine the phenomena factually and specifically.

The centralization of the obtained values on a single map allows a general assessment of the morphodynamic potential, the stability of the surfaces in relation to the natural balance, respectively, the risk level that involves economic activities (location of civil engineering works, housing etc.).

In order to generate a landslides probability map for the study area, we choose the use of the formula given in the GT-019-98 norm:

$$K_m = \frac{K_a \cdot K_b}{6}\left(K_c + K_d + K_e + K_f + K_g + K_h\right) \quad [1]$$

Where, K_a = lithology factor;

K_b = geomorphological factor;

K_c = structural factor;

K_d = hydrological and climatic factor;

K_e = hydrogeological factor;

K_f = seismic factor;

K_g = forestry factor;

K_h = anthropogenic factor.

According to the formula (1), for the assessment of the landslide risk maps eight factors need to be determined for the study area: from the existing geological map and some field investigations we computed the lithology factor; using a high resolution digital elevation model at 25 m EuDEM the geomorphology factor was computed, which stands for slope and hypsometric maps; the area's geological structure was extracted from existing geological maps along with the underground water table level, the hydrogeological factor; because of the small area and the lack of stations climatic and hydrological data were obtained from meteorological stations near the study area (only as constant included); as a constant value was included the seismicity, this is also due to the small spatial extension of the area, this possibility is specified in the GT-019-98 Guide; field investigations, orthophoto data and measurements helped to obtain the land use (mainly forestry factor) and the anthropogenic factors (Sarkar and Kanungo, 2004; Roșian et al., 2016).

Following the methodology, in the last part of the processing phase, all data were converted to raster (100 m spatial resolution), thus resulting in eight raster files (Roșian et al., 2016). After reclassifying the raster data, final scores were assigned according to the six classes required by GT-019-98.

In the final step of the assessment process, all data was included in the formula using the ESRI ArcGIS 10.5 Spatial Analyst/Raster Calculator extension, resulting the landslide probability map (Roșian et al., 2016; Roșian et al., 2021).

3. RESULTS AND DISCUSSIONS

The database processing resulted in the landslide probability map and other graphic materials. Of these, we will refer to the geology and landforms (altitude and slope) to precisely highlight their implications in creating favourable conditions for landslides. Also, because we speak of a territorial administrative unit with over 3,000 inhabitants, a correlation will be made between households and the landslide probability classes.

3.1. Geology. The studied territory overlaps with a complex geological substratum, with formations of different ages, starting from the Miocene to the Quaternary (fig. 2). Following a complex geological evolution specific to the north of the Transylvanian Basin, the Burdigalian, Badenian and Holocene deposits are relatively current. They are the result of erosion and deposition of materials specific to the Carpathian Mountains (Rodna and Țibleș Mountains) (Sanders, 1999; Sanders et al., 2002; Krézsek and Filipescu, 2005; Krézsek and Bally, 2006). These deposits are dominated by friable sedimentary rocks such as clays, marls, sands, and gravels, to which sandstones and conglomerates are added in some places.

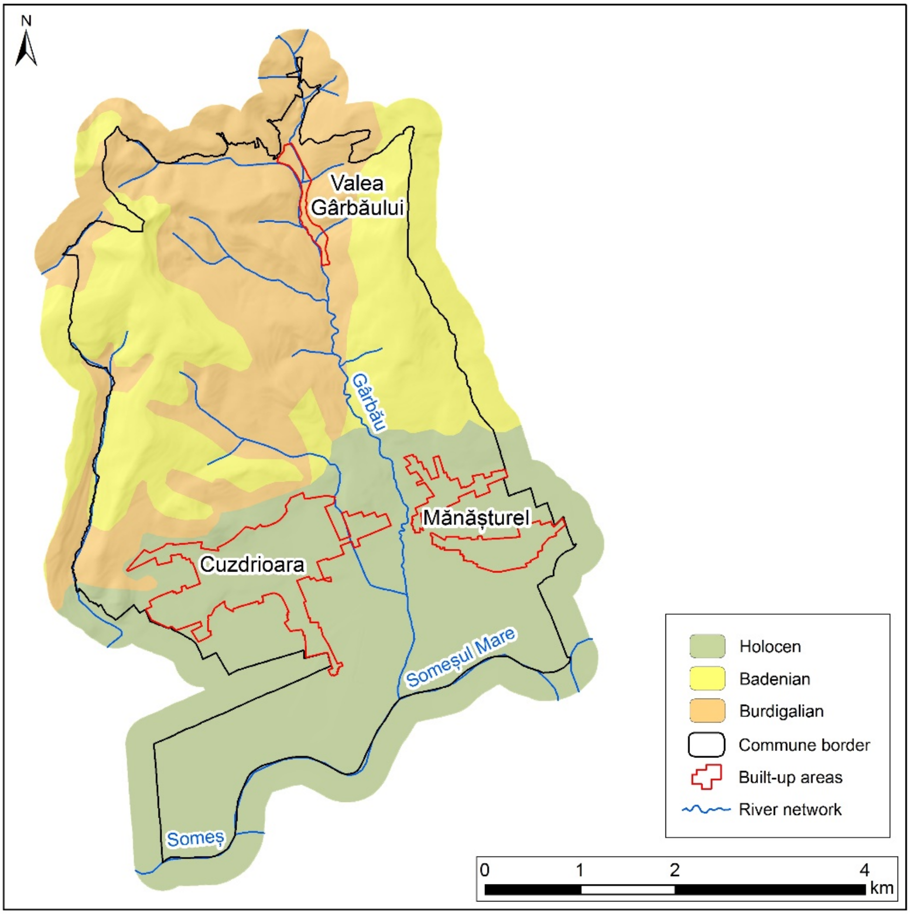

Fig. 2. Geological map

At the same time, due to a substrate made up of friable rocks, also helped by land use, landslide-like geomorphological processes have not been long in coming (Roșian and Horvath, 2019).

3.2. Landform. As can be seen in figure 3, the Cuzdrioara commune overlaps the Someșului Mare Corridor, as well as the hydrographic basin of its tributary, the Gârbăului Valley (it belongs to the Someșan Plateau). The altitudes vary from 231 m, in the Someșului Mare floodplain, to 504 m, in Izvorului Hill. Even if the altitudinal values are not high, the differences being only 273 m, given that they vary rapidly over short distances, it is possible for the slope to exceed 15° on large areas, especially at the level of the steep slopes (fig. 4).

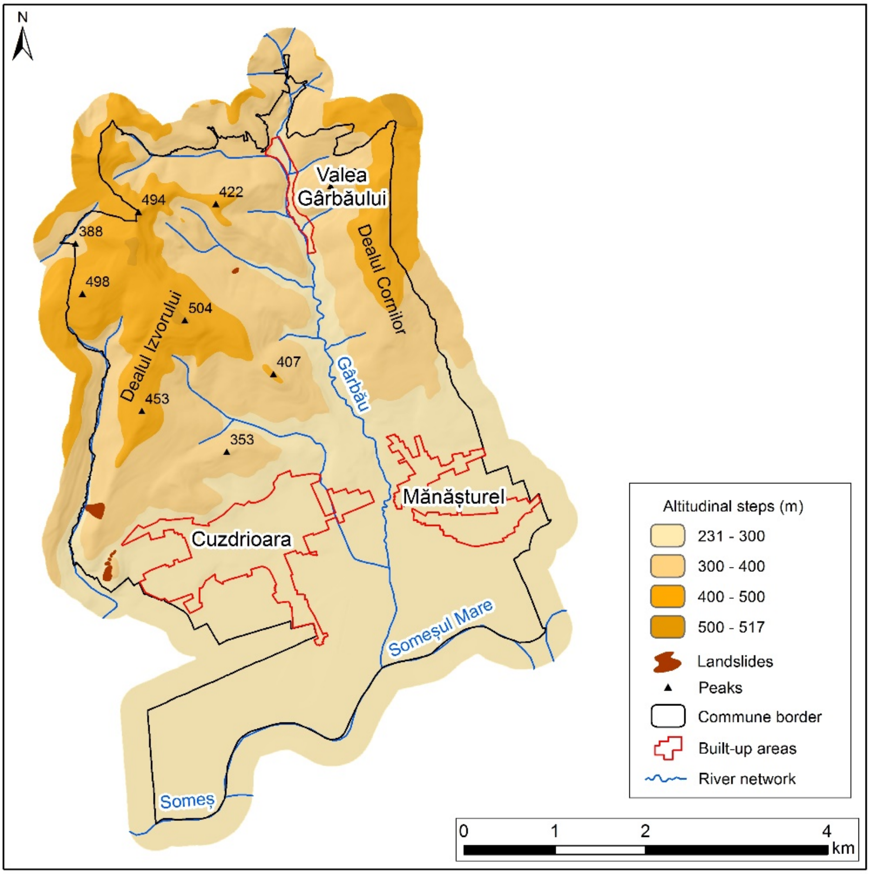

Fig. 3. Relief map of Cuzdrioara

Within the Someșului Mare Corridor next to the meadow are the river terraces. The altitudinal levels of the first two (3-4 m and 8-12 m) allow favorable conditions for human settlements (Cuzdrioara, Mănășturel, etc.) and communication ways (roads and railways).

The right slope of the Someșului Mare Corridor is fragmented by numerous tributaries originating in the Someșan Plateau, among which the Gârbăului Valley stands out. The deepening of it and its tributaries with over 200 m in the Burdigalian and Badenian sedimentary deposits determined the steep slopes, which turned into the most susceptible landforms to landslides. The steep slopes are spread especially on the west of the Cuzdrioara commune, with seven landslides of 3.45 ha being mapped on the slopes belonging to Izvorului Hill. They are also specific to the right slope of the Pocardicului Valley (right tributary of the Gârbău Valley) where a landslide of 0.19 ha has been identified. There are 8 in total, and their surface is 3.64 ha.

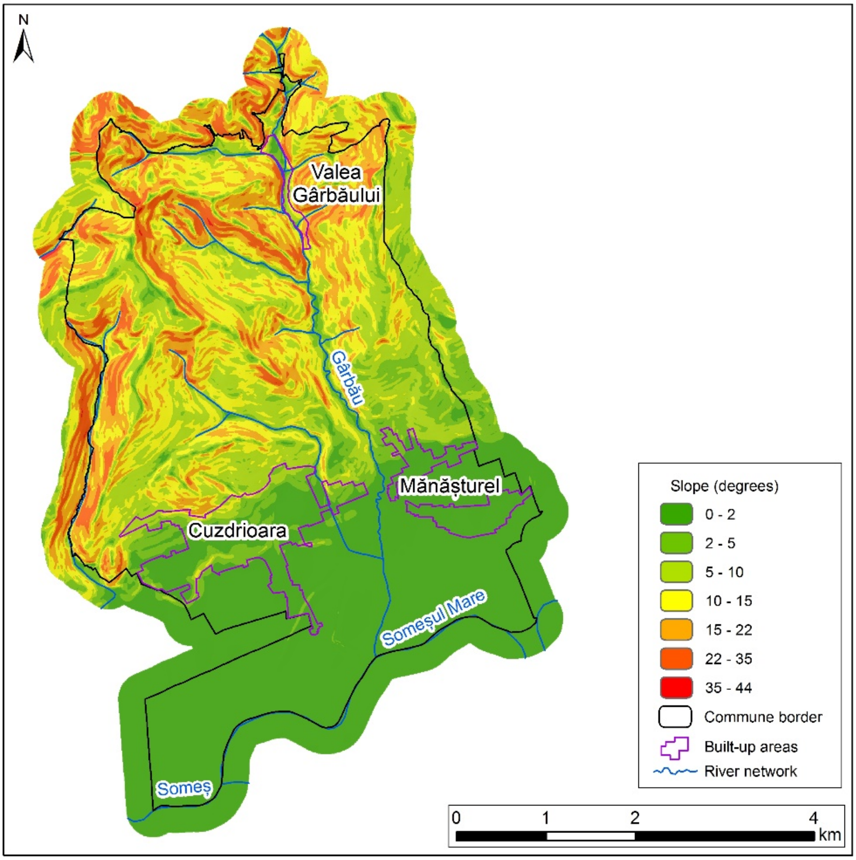

Fig. 4. Slope map

The presence of the eight landslides must be considered a topical issue, given that the occurrence of new landslides will determine the crossing of the affected areas into the unstable land areas category. For this reason, prevention and control measures regarding these processes are needed.

3.3. The probability of landslides. Out of the six probability classes regarding the occurrence of landslides according to Gt-019-98 (practically zero, low, medium, medium-high, high and very high), four of them are present in this case: low (0-0.1), medium (0.1-0.3), medium-high (0.3-0.5) and high (0.5-0.8).

They are graphically represented on the landslide probability map (fig. 5). On this map, one can see that the predisposition of the land to landslides, it is the result of overlapping several thematic maps in raster format representing: lithology, altimetry, slope, fragmentation of landform, riverbeds, geomorphological processes, land use etc.

From the perspective of spatial distribution of probability classes, the following can be noticed for the territorial administrative unit of Cuzdrioara (fig. 5):

- *the low probability class* is found in the southern half of the commune, in the Someșului Mare Corridor (meadow and river terraces), given the low values of the slopes and specific geological deposits;
- *the medium probability class* is also in the southern part, at the contact of the floodplain and the river terraces with steep slopes; it is also rarely found on the Gârbăului Valley and on some of its tributaries (Pocardicului and Hotarului Valley);
- *the medium-high probability class* is representative for the northern half of the commune (specific steep slopes of the right tributaries of Someșului Mare);
- *the high probability class* is characteristic to the slopes in the upper basin of Gârbăului Valley, as well as on the steep slopes in the western part of Cuzdrioara commune.

The values obtained are very balanced and in line with the situation in the field. The probability of landslides in the floodplain area is low (but still with values above zero), while in the case of some steep slopes, this probability reaches the value of 0.78 (high probability) without being included in the very high probability category. Such values are specific to areas affected by active landslides.

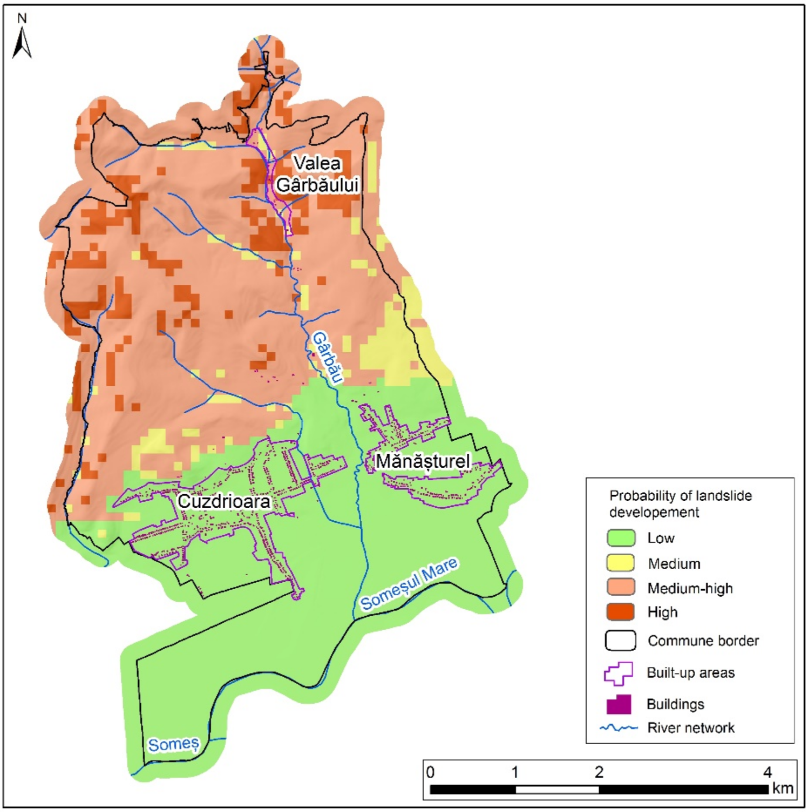

Fig. 5. The landslides occurrence probability map

Correlation between probability classes and number of households. As it can be seen in Table 1, the situation is currently normal in this respect. This means that most buildings are located on areas included in low probability classes (894), medium (4) and medium-high (36), while there are only a few buildings in the high probability class (3).

Given the need for space for new buildings, as it is currently the case, the human pressure will increase on the lands of medium and medium-high probability classes. This means that buildings will be built on areas which are increasingly susceptible to landslides. In addition, if we consider the additional efforts necessary for their foundation, the costs of new buildings will increase. (Roșian et al., 2016).

Table 1. The correlation between the probability classes and the number of households

Probability class	Surface class probability (ha)	Percentage (%) of probability class	Number of households	Percentage (%) of households
Low	1126	46	894	95
Medium	116	4	4	0,5
Medium-high	1063	43	36	4,1
High	169	7	3	0,4
Total	2474	100	937	100

Also, as there are eight landslides, controlling and preventive measures are needed for other future landslides, given that the area is susceptible. Regarding landslide controlling measures, we propose land levelling and land modelling works, unstable land support works (retaining walls), and afforestation. In their turn, the preventive measures refer to works that prevent water access, works for diminishing the influence of the underground waters, planting of shrubs, water drainage works, etc.

4. CONCLUSIONS

Although in the case of the Cuzdrioara commune, there are only eight landslides, with an area of only 3.64 ha (which means only 0.14% of the total area), the susceptibility to landslides, according to the applied methodology, is quite high. This statement is based on the fact that 50% of the area of the commune overlaps with the high medium (43%) and high (7%) landslide probability classes.

The fact that in Cuzdrioara, given the high susceptibility to landslides, they did not occur frequently and did not occupy large areas is also due to the human land use types. Forest represents approximately 35% of the surface, which practically overlaps with medium-high and high susceptibility areas. Also, the floodplains and terraces of Someșului Mare represent 32% of the surface, and even if the arable lands prevail, due to the low slope values (below 2°) there are no landslides.

All this indicates that any other new potential landslides are related mainly to future land use. As long as the most susceptible areas to landslides are forested, landslides will not occur. Lands used as pasture located on areas with a slope greater than 7° are still susceptible to these geomorphological processes.

The classification of lands according to their vulnerability to landslides is beneficial both for territorial planning and development actions and for avoiding the setting of buildings on unstable areas. Understanding the vulnerability to landslides helps local administrations differentiate taxation and insurance companies regarding the area's insurance value. This will force any entrepreneur to comply with local land use plans strictly.

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