LANDSLIDES AND GROUNDWATER DYNAMICS. CASE STUDY IN MOLDAVIAN TABLELAND (ROMANIA)

DOI: http://dx.doi.org/10.18509/GBP.2020.14
UDC: 556.313:551.311.2(498)

Boicu Daniel
Minea Ionuț
Niacșu Lilian
Alexandru Ioan Cuza" University of Iasi, Faculty of Geography and Geology, **Romania**

ABSTRACT

The landslides have an important impact on the evolution of some natural components and the anthropic activities. Often these processes generate difficult to predict side effects. This was the case in the rural area of Moldavian Tableland (located in the eastern part of Romania) where the construction of a water tank for water supply to the local community, generated the production of a landslide on the background of exceptional weather conditions. Side effects were manifested and consist of changes in the morphology of the surface terrain and increasing the water level by 0.5-2 m (observing through direct measurements) compared to the initial level. At the same time, changes in the direction of groundwater flow were observed by blocking the initial directions to the main collector and reversing them to the inhabited area with effects in the flooding (at the level of 2019) of an area with an area of over 5 ha and 17 houses and outbuildings.

Keywords: landslides, groundwater level, modifications, Moldavian Tableland, Romania

INTRODUCTION

Landslides are one of the current geomorphological processes that have a special impact on the environment and human communities. Generally, the scientific studies analyze the evolution of natural [1,2] and anthropic factors [3] that generate landslides. In the same time the effects of these processes on socio-economic systems are also analyzed [4]. These effects are not often local and include a series of modifications of natural components that are difficult to predict. The local geological conditions, the evolution of the climatic elements and the anthropic activity can generate situations that potentiate the local impact of the landslides. This situation is common in the eastern part of Romania, where landslides are one of the most common natural hazards [5]. The presence of the clay deposits [6,7] and changes in land use from the last two centuries [8] with a continuous deforestration increased the vulnerability of the local comunities over this geomorphological risk . Against this geological and historical background, the anthropic actions generated by the vulnerability of the groundwater resources due to the climatic changes of the last decades [9,10] have imposed modifications of the natural regime of variation of the groundwater level and the evolution of the underground water bodies [11, 12]. For example, due to the frequent drought periods that include all natural components [13] for the local communities in the rural area, water tanks with different volumes of accumulation have been created. This type of construction, which is often performed in the highest areas, due to the weight given by the volume of water accumulated, can generate side effects such as the production of landslides and changes in the variation of the groundwater level. This situation practically brings us to analyze the impact of the landslides on the groundwater level, in a settled area, and this is the main objective of this work. Basically, changes are made to the recharging capacity of aquifers [14], which under pressure conditions will generate groundwater accumulations with an effect on increasing the groundwater level and flooding some inhabited areas.

Study area

The analyzed area is located in the central part of the Moldavian Tableland an area frequently affected by landslides (Figure 1) [7]. In certain conditions a series of landslides are generated by special climatic events. Between 19 and 21 of April 2017, the observations regarding the thicknesses of the snow layer recorded in the last decade of this month for the entire studied area were the highest in the last century. In the hilly areas of western Moldova, the maximum values reached 57 cm in Bârnova weather station and in Bârlad weather station 22 cm (after National Meteorological Administration). As a result of the massive advection of moisture-filled polar air from the western Black Sea basin, a significant amount of wet snow fell during this time, which brought significant damage to the vegetation that had already emerged from the cold period. Significant negative effects were also accounted for in terms of traffic on public roads or major damage to the electricity distribution network.

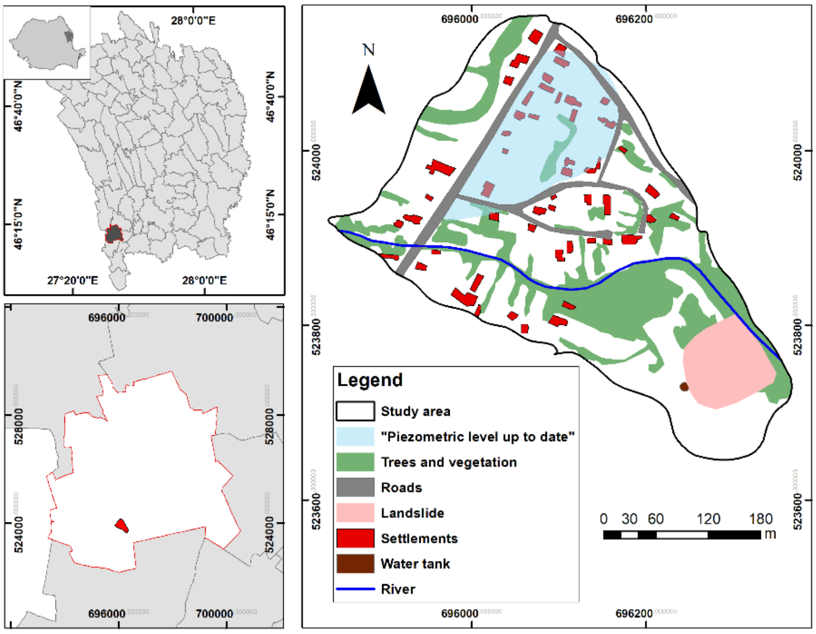

Figure 1. Study area in the central zone of the Moldavian Tableland

Following the event recorded in April 2017, on the edge of the village Iveşti - Vaslui county, on Valea Cărăman, a tributary to the left of Tutova, a landslide was triggered that affects over 1 ha of arable land (vines) and forest protection. The difference of level measured between the ledge and the lowest point is over 30 meters, the whole body of the slide is divided into two, the two detached ledges being impressive, the upper one with an amplitude of over 7 meters, and the one from the middle. of the slope over 7-8 meters. Surveys made with the help of the Eijkelkamp kit, up to a depth of 7 m, have covered sandy deposits of Pontian with very thin marshy intercalations but did not allow the sliding bed to be intercepted (Figure 2).

The sudden appearance of this slip is due to a complex of factors that acted simultaneously. With an area not exceeding 100 ha, Valea Cărămanului is a typical torrential valley, with a high relief energy (35-40 m) and steep slopes of over 30%, specific to the general sandy bottom. Basically, the entire morphology of the area is due to the sculpture made by the continuous ravines, from the bottom of the valley that develops on the thread of the valley. In the winter between 2016 and 2017, following the blocking of the water line with trunks, branches and garbage, a temporary lake was formed inside the ravine, which was broken once with the flood due to the melting of the snow that fell during 19 and 21 April 2017. At the same time, the total cleaning and deepening of the ravine were accomplished, which instantly led to the destabilization of the left bank on a length of about 85-90 m. The regressive movement, typical of a landslide, affected the entire slope over a length of over 100 m, up to near the peaks. Moreover, at the time of production, the main ledge was about 5 meters from the main reservoir of the water distribution network in the village of Ivești. Two years after the event, the landslide has already updated the foundation of the construction, which has caused the authorities to remove it.

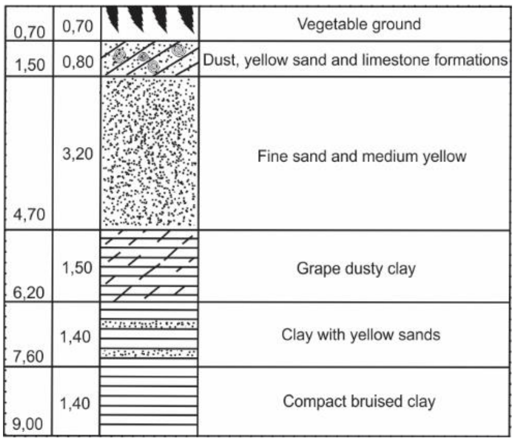

Figure 2. Lithological structure in the middle Moldavian Tableland
(data source Prut-Barlad Water Administration Brach)

Following the successive measurements made between the 2017 and 2019 years, a continuation of the movement on the slope of the material that forms the body of the landslide was observed. At the same time, due to the increased fragmentation of the deluge, the widespread initiation and development of deep erosion forms such as streams and small, discontinuous streams and slopes is noted. In winter between 2018 and 2019, mainly due to the deluvial material reached the bottom of the valley, a new and larger dam was formed. With the thaw in the spring of 2019, although until May the lake was drained, in the whole area of the Cărăman's melting cone was observed the generalized rise of the level of groundwater, in the most affected area the water coming up to the surface.

DATA AND METHODOLOGY

The study of the impact of the landslide in the Cărăman river basin, from the town of Ivești Vaslui county, on the groundwater level was carried out in two stages. The first stage involved the use of GIS software to observe and analyze the morphometric characteristics. The second stage involved moving to the field and taking successive samples on the temporal evolution of the landslide and the groundwater level in the studied area. For the profiling and the comparison with the data from the field, the numerical model of the ASTER GDEM type terrain was obtained from the USGS website (https://lpdaac.usgs.gov/), a model that has a pixel size of 30X30 meters. Based on the satellite images from the Google Earth software, by digitizing, the thematic layers were generated regarding the use of the land. The analysis of the lithological structure was performed based on the reports obtained at the hydrogeological drilling monitored by the Prut-Bârlad Water Administration Branch, managed by National Water Administration. The observations regarding the evolution of the landslide were taken during the field stages, from 2017 and 2018. The successive samples were taken using the theodolite and GPS. Also, measurements on the groundwater level were also obtained during the field stage, in 2019, the measurements were made in 27 points (24 wells and 3 cellars). The instrument used in the sampling of groundwater level data were deep meter.

Table 1. Number of measurments for slip evolution

Date	07/05/2017	07/07/2017	08/09/2018
Number of points	63	206	236

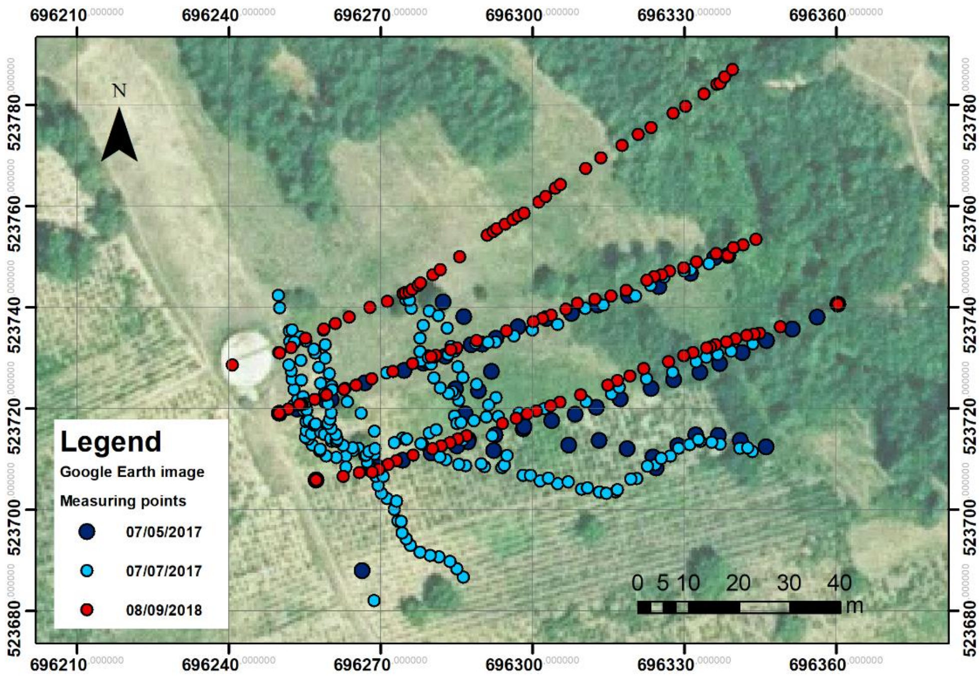

Figure 3. Measuring points in the area studied

RESULTS

The analyzed area was characterized by a classical underground water dynamic. The general directions of water drainage in the underground follow the lines of the largest slopes so that the hydrographic network represents the areas of concentration of groundwater currents as observed from the initial model represented in figure 4. The level of groundwater in the area, initially, varies between 1.5 and 2 m depending on the plot against the main collector and sources. In the interfluvial zone the groundwater level exceeded 5 m due to the conditions of water storage in the hydrogeological structures specific to the Meotian deposits with alternatives of fine sand, dusty clay and clay.

Over the time, in the area, there have been modifications of the relief. Obviously, some anthropic activities on the relief have imposed over the time slight modifications by carrying out rambles for the transport network that have induced changes in the direction of the flow of groundwater through changes in the surface morphology of the land and the underground blockage of the leak to the main collector (figure 5). In parallel, the main collector has undergone an easy seaming process which in the last 30 years has led to the modification of the level of the trough and to the blockage of the surface leakage at the level of the bridges. The elevation of the level of the trough measured on the ground reached in some places values of 1.5 – 2 meters. This impacted on the local groundwater level that registered, according to the information obtained from the local residents, slight increases to the surface of the land with 0.2-0.5 meters. After the construction of a water tank, between 2015 and 2017, for supplying the population in a centralized water system, the following year there was a marked increase in the slopes level by creating favorable conditions for the production of a landslide. This landslide became active during the years 2017-2018, as can be seen from figure 6.

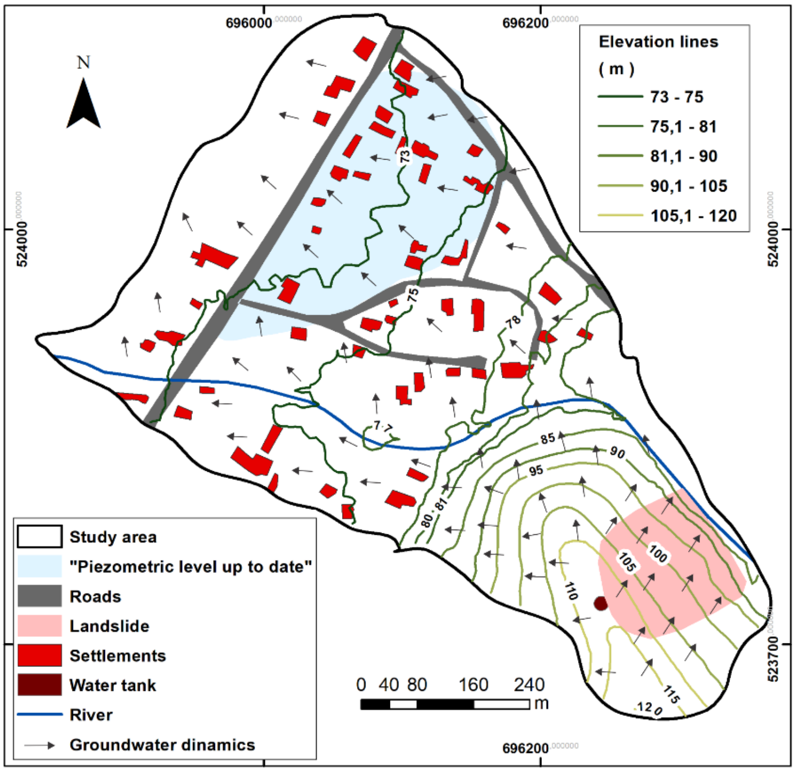

Figure 4. Initial model of the groundwater dynamics in the study area

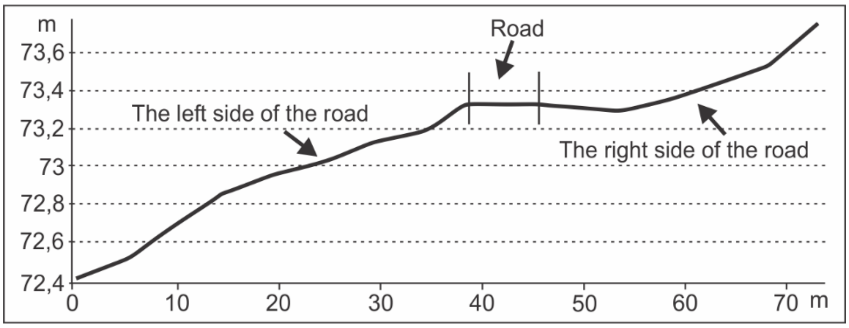

Figure 5. Changes in the morphology of the land surface through the construction of the transport network

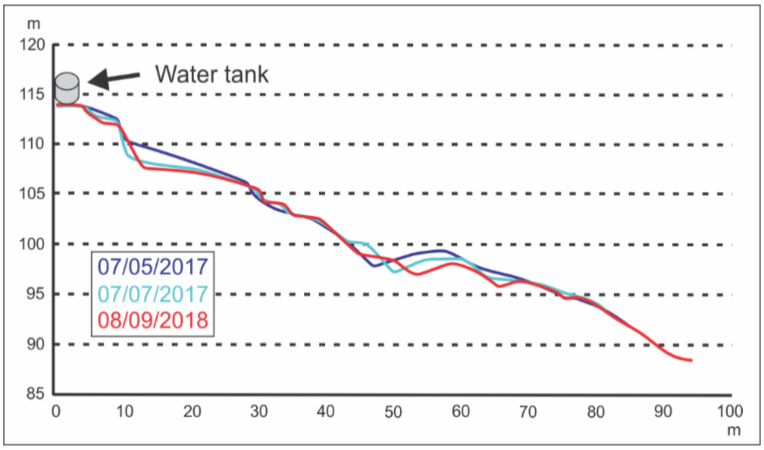

Figure 6. Landslide dynamics under the water tank between 2017 and 2018

Pushing the sliding dislocated material to the main collector caused the leakage to be blocked both on the surface and underground so as to melt the snow in the spring of 2019 and the total summer rainfall of the same area throughout the area, between the transport path, the main collector, and the base of the slide, was flooded. The measurements made in the field in the Spring of 2019 revealed that about 5 ha of the agricultural and built area was flooded and 17 houses and dependencies suffered as a result of the groundwater level increase which is sometimes 10-20 cm from the surface of the land. At the same time, at the level of groundwater dynamics, a blockage of its natural flow towards the main collector was observed and the direction reversed towards the inhabited area. The effect as presented above is to increase the groundwater level up to very close to the surface of the land and to flood some houses and dependencies.

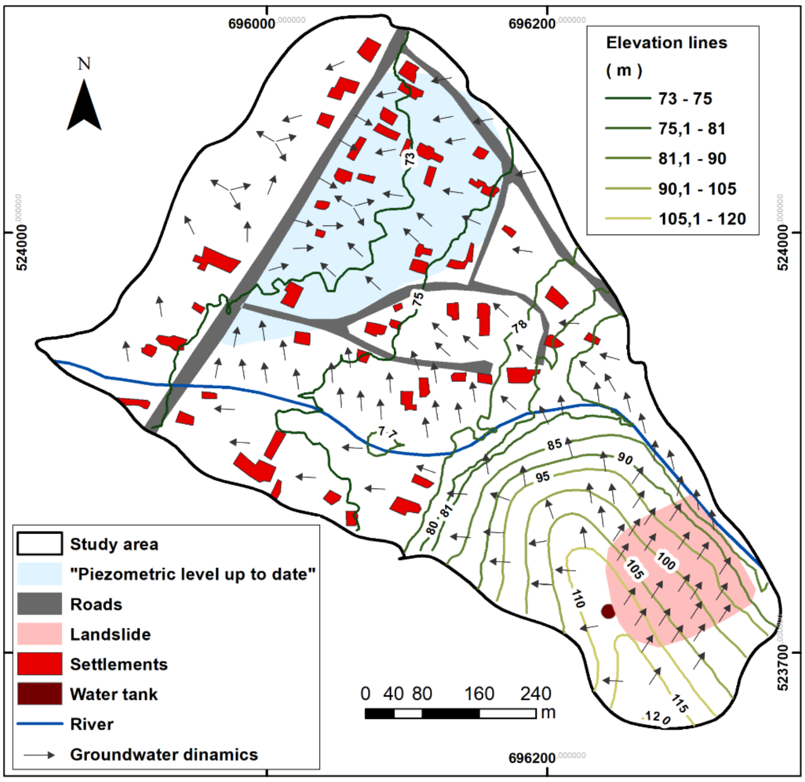

Figure 7. Model of the groundwater dynamics in the study area after appearance of landslide

CONCLUSIONS

Underground water dynamics follows, most often, the shape of the topographic surface and some actions that are imposed on the relief, whether they are due to natural or anthropic causes, can generate changes on the dynamics of groundwater. The impact of climate change starting from consecutive years of drought has forced the construction of a water tank on the edge. The weight of the construction superimposed on the predominantly clay and sandy deposits, against the backdrop of periods with excess rainfall, generated the detachment of a mass of earth. Deforestation of the area favored a steep advance of the landslide, thus generating stress on the groundwater downstream. The modernization of the transport network has resulted in the settlement of the lithological substrate. The generated ramp blocked the underground drain to the main collector down the road, the Tutova river. All these changes led to the raising of the groundwater to the topographic surface and to the emergence of the “groundwater level up to date” phenomenon for an area of approximately 5 ha and a number of 17 houses. Avoiding the accumulation of groundwater upstream of the stream as well as the return to conditions of underground drainage prior to the processes identified in the work can be achieved by creating drainage channels under the stream, thus simulating the natural water circuit.

Aknowledgements
This work was financially supported by the Department of Geography from Faculty of Geography and Geology, “Alexandru Ioan Cuza” University of Iasi.

REFERENCES:

[1] Brönnimann C.S., Effect of Groundwater on Landslide Triggering, EPFL Scientific Publications, Lausanne, Switzerland, 2011.

[2] Weng C.H., Lin M.L., Lo C.M., Lin H.H., The Influence of Groundwater on the Sliding and Deposition Behaviors of Cataclinal Slopes, Water, 10, 1179, 2018.

[3] Meusburger K., Alewell c., Impacts of anthropogenic and environmental factors on the occurrence ofshallow landslides in an alpine catchment (Urseren Valley, Switzerland). Natural Hazards and EarthSystem Science, 8 (3), 509-520, 2008.

[4] Perera E.N.C., Jayawardana D.T., Jayasinghe P., Bandara R.M.S., Alahakoon N., Direct impacts of landslides on socio-economic systems: a case study from Aranayake, Sri Lanka, Geoenviron Disasters, 5: 11, 2018

[5] Ioniță I., Chelaru P., Niacsu L., Butelca, D., Andrei A., Landslide distribution and their recent development within the Central Moldavian Plateau of Romania, Carpathian Journal Earth Environmental Sciences, 9, 3, 241-252, 2014.

[6] Niculiță M, Mărgărint MC, Santangelo M, Archaeological evidence for Holocene landslide activity in the Eastern Carpathian lowland, Quaternary International, 415(10):175-189, 2016.

[7] Margarint MC, Niculita M., Landslide type and pattern in Moldavian Plateau, NE Romania. In: Rădoane M, Vespremeanu-Stroe A (eds), Landform Dynamics and Evolution in Romania. Springer 271–304. 2017.

[8] Stanga IC, Niacsu L (2016) Using old maps and soil properties to reconstruct the forest spatial pattern in the late 18th century. Environmental Engineering and Management Journal 15(6):1369-1378. WOS:000383100900019

[9] Minea I., Croitoru A.E., Climate Changes and their impact on the variation of groundwater level in the Moldavian Plateau (Eastern Romania), International Multidisciplinary Scientific

Geoconferences, SGEM 2015, Conference Proceedings, Vol I, Hydrology and Water Resources, 137-145, 2015.

[10] Gariano S.L., Guzzetti F., Landslides in a changing climate, Earth-Science Reviews, 162, 227-252, 2016.

[11] Minea I., Croitoru A.E., Groundwater response to changes in precipitation in north-eastern Romania, Environmental Engineering Management Journal, 16, 3, 643-651, 2017.

[12] Minea I., Crăciun I., Simulation models to evaluate the groundwater resources in Bahlui river basin, Romania. Journal of Environmental Protection and Ecology, 1600-1607, 2012.

[13] Minea I., Butelcă D., Niacşu L., Modele de variaţie a nivelului freatic în condiţii de secetă. Studiu de caz bazinul superior al Bârladului, Geographia Napocensis, IV, 1, 75-82 (in Romanian), 2012.

[14] Boicu D., Minea I., Chelariu O.E., Iosub M., Evaluation on groundwater recharges capacity using AHP method. Case study: The Moldavian Plain, Aerul şi apa componente ale mediului, 181-188, 2019.