The influence of the climatic factor on the evolution of landslides in the Ialomita Subcarpathians post year 2000. Case studies

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Abstract: - The subcarpathians between Dâmbovița and Ialomița valleys are characterized by strong morpho-dynamics set by the simultaneous existence of geo-mophological factors having a highly morpho-dynamic potential. If a series of factors do not change or rather change slightly through time (e.g. geological conditions, morphometry land usage), the climatic factor is characterized by a high degree of variability both from the point of view of time intensity distribution. Be it that there are high amount of rainfall within a 24-hour period, or that rainfall occurs at the same time as snow melting on a over-humid soil it often triggers landslides. Between 2000 and 2010 numerous landslides occurred and many others were reactivated in the Subcarpathian area between Dâmbovița and Ialomița valleys. The analysis of the several landslides (at Gheboieni (Mărgineanca) – 28 – 31 July 2004, Pucioasa – 26 September 2005, Nicolăeşti (Vulcana Băi) 16 – 17 March 2006 and Micloşani 19 – 23 February 2010) gives us information regarding the direct link between rainfall and landslides. Correlation between the time when rainfall and landslides occur can establish the importance of the role precipitations have in triggering landslides.

Key-Words: - landslides, rainfall, Subcarpathians, triggering

1 Introduction

Current geomorphological processes are the clearest expression of the interaction between the morpho-dynamics potential of a given region and the extreme climatic phenomena. In this respect, reporting the triggering or reactivating of landslides at dates where significant precipitation was registered is very important so as to identify an average duration from the manifestation of excess moisture to the triggering of gravitational processes. Of course, you must also consider the other factors responsible for morpho-dynamics.

Subcarpathians between Dâmbovița and Ialomița are, from this point of view, an area prone to slope processes and thus an area suitable for morphological observations.

Interest in landslide study so far can be grouped into three categories: general studies (Bălteanu, 1983, Grigore and Achim, 2003), studies to determine the morpho-dynamic potential of some areas (Zacharias et al., 2011, Grozavu et al., 2012, Nicorici et al., 2012, Ilinca and Gheuca, 2011) and studies to determine the relationship between the triggers factors and landslides (Constantin, 2002, Loghin et al., 2009;).

Regarding landslides in the Subcarpathian area between Dâmbovița and Prahova valleys, there is an interest in analyzing the causes and effects of landslides in the last 50 years (Mihailescu, 1959, Loghin, 1973, 2002, Dinu and Loghin, 1997, Loghin et al., 2010, Istrate, 2005).

The Subcarpathian area between Dâmbovița and Prahova valleys stands out due to a distinct geographical landscape, a synthesis of a specific association and development manner of elements and natural and socio-economic processes. This section of the Subcarpathian as the Curvature Subcarpathians in their entirety, stand out through the complexity of geology and topography. The research area is in a complex geological setting, easily eroded fragile rocks predominance and the ever-present plastic rocks (clays, marls), generating landslides, are typical traits of the Subcarpathian foothills (Popp, 1939, Loghin, 2002).

Peaks and valleys, as basic forms of relief, correspond to anticlines and respectively to sinclines. On a NE-SW direction there are several rows of hills and depressions. Thus, depression areas such as Moroieni - Runcu - Pucheni and Bezdead - Buciumeni - Costesti alignments are separated by anticline hills (Oncescu, 1965; Mutihac, 1990). But these overall patterns are blurred by strong fragmentation caused by major and minor hydrographic network of a primary and secondary nature.

It is important to note that in the specific natural conditions and at the extent and manner of their transformation by man Subcarpathian hills are characterized by accelerated processes of shaping riverbeds (river-torrential erosion) and slopes (washing, runoff, gullying and ground shifting: landslides, mudflows), highlighted by the widespread nature of land degradation, especially of arable land on the slopes.

Given the high frequency of landslides in this area, we focused on the analysis of several representative case studies, both as a means unfolding and as a seasonal distribution (fig. 1).

2 Materials and methods

Geological and geomorphological peculiarities of the analyzed area favors the development of slope processes which can be triggered or reactivated in the presence of meteorological parameters, among which we can mention: space-time evolution of the air, especially in the beginning or end of the cold period of the year, rain, mainly by its amount and intensity.

The rainfall monthly average/year ranges between 600-900 mm / year, with an unequal distribution (65-70% during the warm season of the year, the difference being registered in the cold season of the year). Maximum values are generally registered between June-July (often over 100 mm), which corresponds to cyclonic activity and more intense convective thermal processes. Small amounts fall, usually in late autumn and winter, when prevalent is the anticyclonic regime and thermal-convective processes decrease in intensity (Murărescu and Brețcan, 2008).

Regarding annual number of days with precipitation greater than or equal to 0.1 mm, it ranges from 127 in the interference area with the High Plain of Târgovişte, and 135 in the Subcarpathians and from a monthly perspective, it ranges from 14 days (from December to May) and 12 days (June-November) (Murărescu, 2004).

In terms of time, precipitation ranges from 5-12 minutes to 10-12 hours. High intensity precipitation fall mainly in Summer from convective clouds in the form of rain, which may lead to intense erosion, as well as to the onset of torrential rainfall. The intensity of this type of precipitation varies between 2.4 and 3.5 mm / min (Murărescu and Pehoiu, 2009).

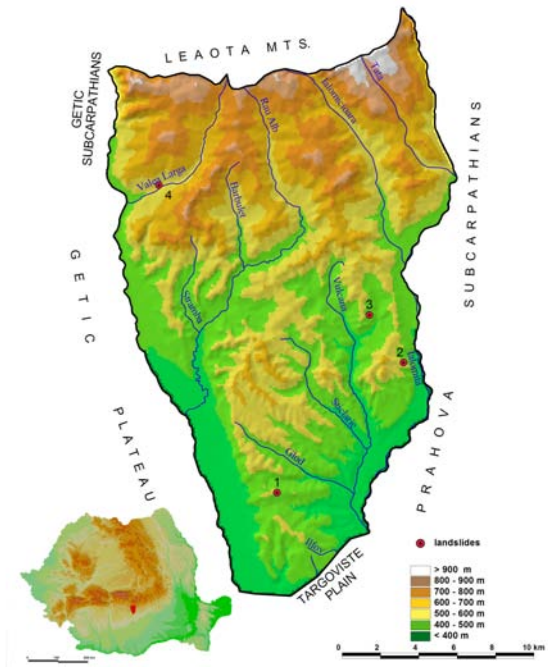

Figure 1. Distribution of analyzed landslides in the Ialomița Subcarpathians 1. Gheboieni (Mărgineanca); Pucioasa; 3. Nicolăeşti (Vulcana Băi); 4. Micloşani

After analyzing the multi-annual monthly average quantities between 1961-2010 we can see that in February at the interference area with the plain, the average is 33.5 mm, 34.1 mm in March, 81.6 mm in July and in September 35, 1 mm. In contrast, in the Subcarpathians, the February average amount of precipitation is 30 mm, 49.6 mm in March, July 82.5 mm and 62.4 mm in September (Murărescu et al., 2008; Murărescu and Pehoiu, 2009).

To determine the relationship between rainfall and slope geo-morphological processes (landslides) daily rainfall values for each month from Târgovişte Meteorological Station (297 m alt.), rainfall stations Râu Alb (600 m alt.), Valea Lungă (322 m alt.) and Dealul Frumos (651 m alt.) were taken into account.

Compared on a multi-annual monthly average precipitation basis, the months analyzed are characterized by significant quantitative overruns recorded at Târgovişte Meteorological Station (fig. 2).

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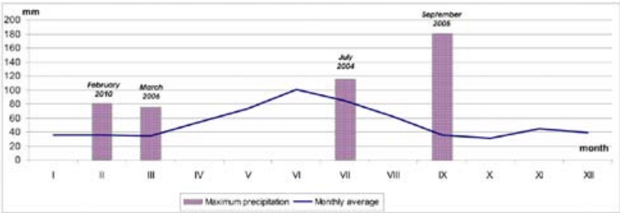

Figure 2. Average monthly precipitation quantities on an annual level and values registered in the analyzed months at Târgovişte Meteorological Station

3 Results

The cases of landslides that were analyzed and whose data was identified from field observations or study of specialized literature and local press were those from Gheboieni (Mărgineanca) – 28th to 31st of July 2004, Pucioasa - September 26th, 2005, Nicolăeşti (Vulcana Băi) 16th to 17th of March 2006 and Micloşani 19th to 23th of February 2010 (fig. 1).

A comparative analysis can be made of the influence of rainfall on the trigerring or reactivation of landslides in the geographical area under study, namely: during the warm season, when precipitations fall in liquid form and the cold semester or transition period between seasons, when there is a combination of solid and liquid precipitations and the melting of snow caused by warm air masses entering Romania.

In the case of the landslides that occurred between the 28th and 31st of July 2004 (fig. 3), by analyzing the daily monthly precipitations, a distribution per decade can be seen: in the first decade of the month, precipitations were recorded between days 3 to 6, with amounts of 2.1 to 40.5 mm; in the second decade, the precipitations were concentrated in the days between 11 and 14 with amounts that varied between 3 and 47 mm; the third decade of July was the rainiest, with precipitations falling within about a week, with values from 4,2 to 22,5 mm (fig. 4a). Summarized, rainfall exceeded 100 mm for each position (Târgovişte 115,9 mm, Râu Alb 108,3 mm, Dealu Frumos 138,6 mm, Valea Lungă 135,8 mm).

From the graph (Fig. 4a) it can be observed that the landslide was triggered on July 28, to the end of days with precipitation.

In the second case, i.e. landslides in the area of Pucioasa, dated September 26, 2005, the monthly rainfall distribution is also split into three monthly decades, but with a massive concentration point at the end of the second decade and at the beginning of the third, when within a 24-hour time span precipitations ranged between 0.7 and 123 mm. The total monthly precipitation amounts were 180.4 mm - Târgovişte, 241.8 mm - Râu Alb, 273.1 mm Dealu Frumos and 199.1 mm – Valea Lungă, following which, the landslide was reactivated on 26-27 September following rainfall (fig. 4b).

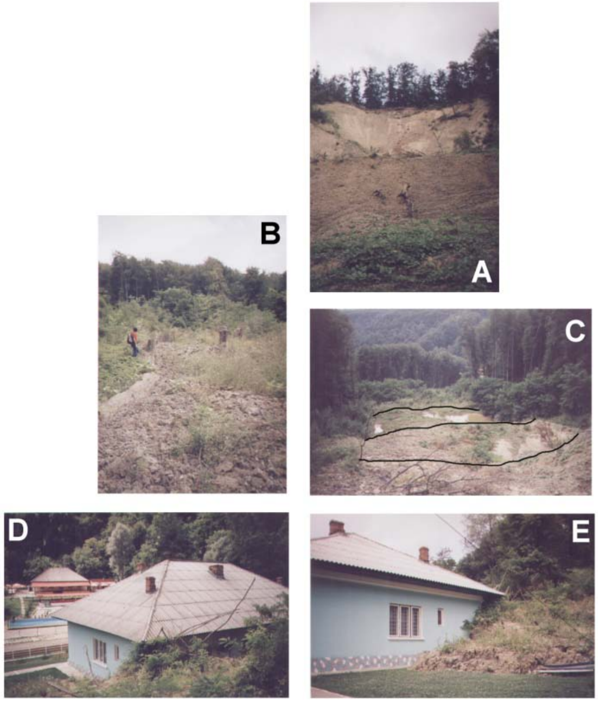

Figure 3. Stages of landslide at Mărgineanca: A. Ditch detachment; B. Wattlework destroyed by slides; C. Steps of landslide; D, E. Villa B from the Mărgineanca champ affected by landslide(Păunescu & Murătoreanu, 2005)

In the case of landslides which occurred at the end of winter and early spring in February 2010 and March 2006 there was the influence of snow layer melting over which, because of warm air masses mixed and liquid precipitation fell. Due to temperature increase it even got to the point of melting the snow layer completely, which led to an overly-humid substratum.

In the first case, the landslide from Nicolăeşti (Vulcana-Băi) on 16 - 17 March 2006, it appears that the highest amounts of precipitation fell in the Subcarpathian area, mainly in the second decade of the month, when the values ranged between 1 and 27.2 mm, for a period of approximately 8 days. Throughout the month, the quantities of rainfall totaled values of 75.5 mm at Târgovişte, at Râu Alb - 147.6 mm, 126.4 mm at Dealu Frumos and 105.1 mm at Valea Lungă.

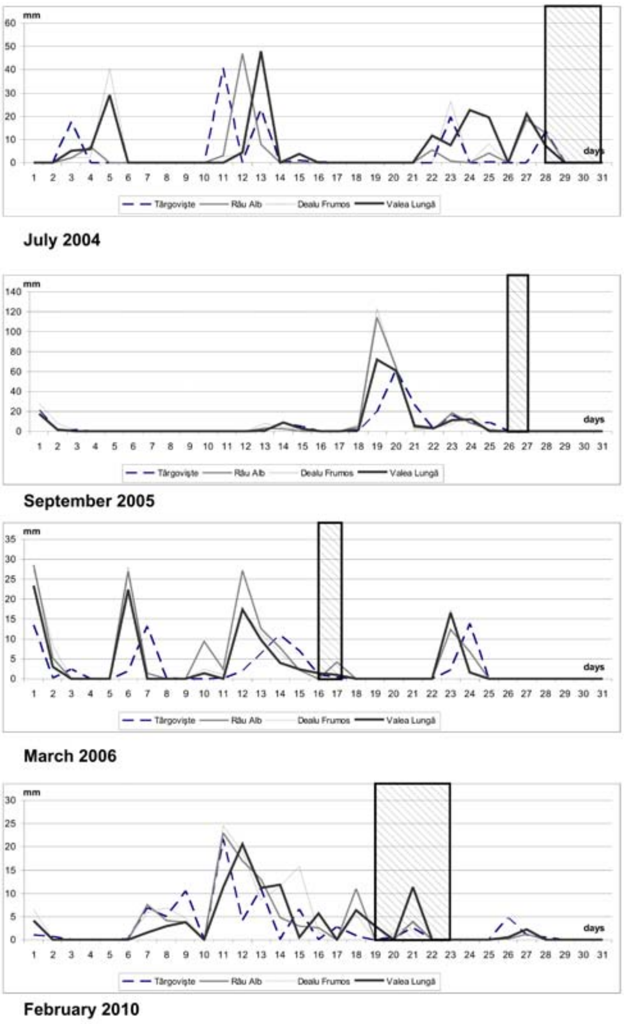

Figure 4. A comparison between daily precipitationsregistered at the selected meteorological stations and rainfall stations and the data regarding landslide manifestationa. Gheboieni (Mărgineanca) – 28 – 31 July 2004, b. Pucioasa – 26 September 2005, c. Nicolăeşti (Vulcana Băi) 16 – 17 March 2006, d. Micloşani 19 – 23 February 2010; A – the period of snow melting

Analyzing from a temporal point of view the quantitative evolution of rainfall it is observed that between 1 and 7 March rainfall was in solid form which allowed the thickening of the snow layer up to 23 and 30 cm.

As of March 11, rainfall was in liquid form, due to the ingress of warm Mediterranean air masses, which made the snow layer decrease steadily until its complete melting on 17 March.

Along with snow melting, liquid rainfall is also observed, which, within just 6 days amounted to the yearly March average of 42.7 mm. Landslides occurred between March 19 and 23, following previous rainfall (fig. 4c).

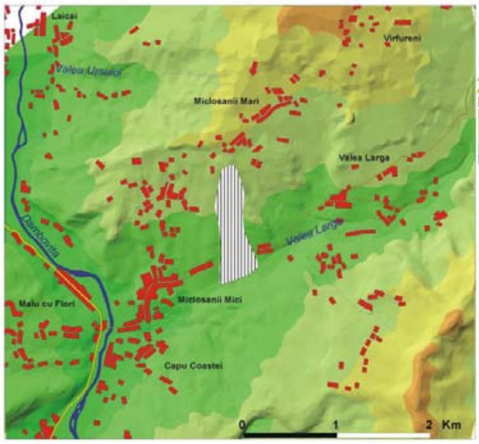

Figure 5. Locating the landslide at Micloşani 2010 (Loghin et al., 2010)

The last discussed case, the Micloşani landslide (fig. 5, 6) between the 19th to 23rd of February 2010, occurred due to the precipitation quantities that fell between the 7th -18th when their values were 0.2 -24.5 mm. The monthly total precipitation amounts recorded were 80,7 mm at Târgovişte, 99,1 mm at Râu Alb, 117,6 mm at Dealu Frumos and 97,2 mm at Valea Lungă(Fig. 4d).

In this case we can again see the influence of water resulting from melting snow due to the temperature increase and also to liquid precipitation fallen particularly between February 20 to 21. If in early February, the snow layer thickness was 19 cm, there is an increase of up to 44 cm of thickness on the 11th due to heavy precipitations in solid form (48,5 mm), after which a slight decrease in the thickness of the snow layer is observed until the 20th when it reaches 17 cm, until it disappears completely in between the 20th and the 23rd. The overlapping of the liquid precipitations with water from melting snow has helped trigger the landslide in Micloşani.

The effects of these landslides were generally minor, being represented by damage to several public buildings and infrastructure (roads, household annexes, Mărgineanca School Camp, etc). The Micloşani landslide was an exception, as it caused major effects in the area of Pucheni village (Micloşani Village), with the total destruction of county road linking Malu cu Flori and Pucheni on a distance of about 0,5 km, damaging power lines and water pipes on that section, destroying the works of drainage (drainage channel) and related poplar plantation, afflicting the agricultural area (apple orchards, meadows, pastures) and narrowing the Valea Largă creek bed and even temporarily blocking it in a particular sector (Loghin et al, 2010).

Moreover, the occurrence of this landslide has mobilized both local authorities and the government, who got involved to solve the crisis caused by this event.

Fig. 6. Effects of Micloşani landslide (2010)

4 Conclusion

From the above case studies we can notice a strong correlation between the amounts of rainfall falling mainly in the Subcarpathian area and the triggering or reactivation of landslides caused or influenced by the lithology of the area.

It is noted that these events occurred following heavy rainfall which were two to three times heavier than the multiannual monthly average for the period 1961-2010. In the case of phenomena of late winter - early spring (February-March) precipitation is added to the water resulting from melted snow due to high temperatures.

Both for spring and summer, the quantities of water infiltration before landslides occur were sufficient to over-humidify the clay or clayey-marly substrate so under excess rainfall landslides are imminent.

Similar studies on other Subcarpathian areas, but mainly on the Curvature Sub-Carpathians areas showed a direct relationship between rainfall and the triggering or reactivation of landslides due to rainfall intensity (Grecu, et al., 2010), and their distribution according to seasons (Dragotă, et al., 2008; Loghin et al 2009).

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