UNIVERSITY „BABEȘ BOLYAI" CLUJ-NAPOCA

FACULTY OF GEOGRAPHY

DOCTORAL SCHOOL OF GEOGRAPHY

PhD THESIS

CLIMATIC HAZARDS AND RISKS ASSOCIATED WITH GEOMORPHOLOGICAL PROCESSES IN THE REGHIN HILLS

- summary -

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Cluj-Napoca

2017

CONTENT

INTRODUCTION

Starting from the interpretation of risk as a product between hazard and the vulnerability of anthropogenic structures, in this study we propose a quantitative and qualitative analysis of meteorological and geomorphological phenomena with risk potential as well as the analysis of the geomorphological risk to which the population from the geographic area of the Reghin Hills.

In order to achieve the proposed goal the research activity had as main directions of action: analysis of the parameters defining the meteorological phenomena with risk potential through some indicators; identification and inventory of current geomorphological processes; Mapping of areas susceptible to hazardous geomorphological processes; identifying and analyzing the factors that influence the geomorphological phenomena with potential risk in the analyzed area; assessing land susceptibility to mass and erosion processes; the estimation of the vulnerability of the population to geomorphological processes and the development of the geomorphological risk map for Reghin Hills.

The use of methods and means specific to geographic research has, in the present study, pursued the most accurate processing of the data we had at our disposal and, as a result of this, we wanted to highlight the risks associated with climatic and gemorphological processes, constitutes a direct or indirect threat to the functionality of the territorial system of the Reghin Hills.

Keywords: climatic hazard, vulnerability, geomophological risk, geomorphological processes, preventive measures, Reghin Hills.

1. NATURAL RISKS: CONCEPTS AND METHODS OF RESEARCH

The hazard involves an energy discharging, which, given the overlapping or spatial intersection between the event's manifestation area and a populated vulnerable area, may have negative effects on the human community. The hazard is the causal and spatial-temporal phenomenon that can not be predicted and the risk indicates the likelihood of damaging (material and human) to a hazard.

I. Ianoş (2000), depending on the effects on the internal structure and functionality of the systems, classifies the consequences of hazards in: accidents, functional ruptures, and catastrophes.

In a wider context, the concept of **vulnerability** can be defined as the susceptibility of a system being affected by a particular internal or external factor that can cause an imbalance.

Mac and Petrea (2003) define vulnerability as the susceptibility of social and biophysical systems to suffer individual and/or collective damage.

The susceptibility to loss is correlated with the sensitivity, resilience and fragility of the community affected by extreme phenomena.Vulnerability assessment is a very complex approach in view of the multitude of factors of influence that increase the susceptibility of a community to extreme events.

According to the IDNDR dictionary (1992), the **risk** is *"the possible number of human losses, injured persons, damage to property and interruptions of economic activities during a reference period and in a given region for a particular natural phenomenon."*

Unlike hazard, the risk is closely linked to the human community, able to be aware of the causes and consequences of the extreme (random) phenomenon, and to adopt certain behavioral responses in response to the event.

Accordingly, the risk is a function of hazard (H) and vulnerability (V) and is defined as the probability of affecting an element (s) within the ensemble resulting from an event of greater intensity than (i)) (Meia-Navarro et al., 1994 quoted by Roşian, 2011)

1.5. The used research methodology

The activities undertaken in order to achieve the objectives of the research were carried out in three stages: the documentation stage, the stage of the field and the stage of analysis and interpretation of the results.

The analysis of the parameters defining climatic phenomena was made on the basis of the data recorded at the meteorological stations and the pluviometric stations existing on and near the analyzed area: Târgu Mureş meteorological station (1978-2008), Batoş meteorological station (1987-2008), Gurghiu and Eremitu pluviometric stations (1978-2008).

The analysis of climatic hazards was achieved through basic climatic indicators: averages (annual, multiannual, monthly, seasonal), maximum and minimum (annual, monthly, seasonal), deviations from average values, frequency of phenomena production, degree of insurance of different values etc.In order to identify the surplus and rainfall thresholds, the pluviometric character of each year and months was established by the Hellman method, Standardized Precipitation Anomaly (SPA) and Angot Idices.

The analysis of the susceptibility of the slopes of mass movement processes was based on the Weighted-Overlay method (Guzzetti et al., 1999, Watts, 2010) and focused on the analysis of the main factors of landslide control. Estimation of the average soil erosion rate was achieved using the Universal Soil Loss Equation (USLE) proposed by W.H. Wischmeier and D.D. Smith (1978), and the assessment of vulnerability to geomorphic hazards was achieved by the Inverse Distance Weighting (IDW) method.

2. GEOGRAPHICAL PREMISES OF NATURAL HAZARDS IN REGHIN HILLS

2.1. Physical and geographic premises

2.1.1. Geographic position

Reghin Hills is the compartment centered on the Mureş valley of the subcarpathian hill alignment located on the internal framework of the Eastern Carpathians (Subcarpathians of Transylvania, Mac, 1972), between the exit of Mureş from the Topliţa-Deda and the interfluvial valleys between Teleac and Căluşer valleys, witch marks the southern boundary near Ernei.The Bistrita Hills (N) and the Transylvanian Plain (V) are delimited by Luț Valey, and to the east it overlaps with the piedmont mountain range of Gurghiu and Căliman (Pop, 2001).

2.1.2. The lithology

Reghin's geological and petrographic hills belong to the eastern and northeastern branches of the Transylvanian Basin, consisting of the states of the Quaternary-Neogen system with the Holocene-Pleistocene, Panonian-Sarmatian series.

2.1.3. The relief

The depression component is represented by the depressions of Vălenii de Mureş, Reghin-Gurghiu and the Dumbrăvioara contact depression, and the hilly component is represented by Sub-Carpathian summits of Sieu-Sânioara and the Teleac Hills.

2.1.3.1. Morphometric features of the relief

2.1.3.1.1. Altitude of the relief

Hypsometric, the Reghin Hills are classified as sub-carpathian hills, with altitudes rising from the Mureş Corridor (300 m) to the piedmont area of Căliman and

Gurghiu Mountains (800 m).Mostly dominate the altitude ranges between 401-500 m and 501-600 m, with a weight of 39.5% and 25.5% of the total area.

2.1.3.1.2. The inclination of the slopes

The inclination and shape of the slopes is an expression of relief modeling, being in close coordination with the lithological, hydrographic, biopedo-climatic and anthropic factors.

The degree of inclination of the slopes has direct implications for the development of some slope processes as well as the land use.

2.1.3.1.3. The density of fragmentation

Density of fragmentation in the Reghin Hills generally has values ranging from 1.1 to 2.5 km/km^2.With the highest values of fragmentation density (over 3.5-4 km / km2)are recorded in the confluence areas and in the sub-mountain area.

2.1.3.1.4. Depth of fragmentation

The frequency histogram of the depth of fragmentation highlights the dominance of the 75-100m (27%) class, followed by the 50-75m (19.6%) and 150-200m (18.0%) classes. The high values of the depth of fragmentation, 200-250 m and over 250 m, characterize 2,2% and 0,4% of the total area and are found in the area of Sâniaora Hills, Osoi Hills, Măgura Hills, Cetăţii Hills, which appear in relief as erosion witnesses.

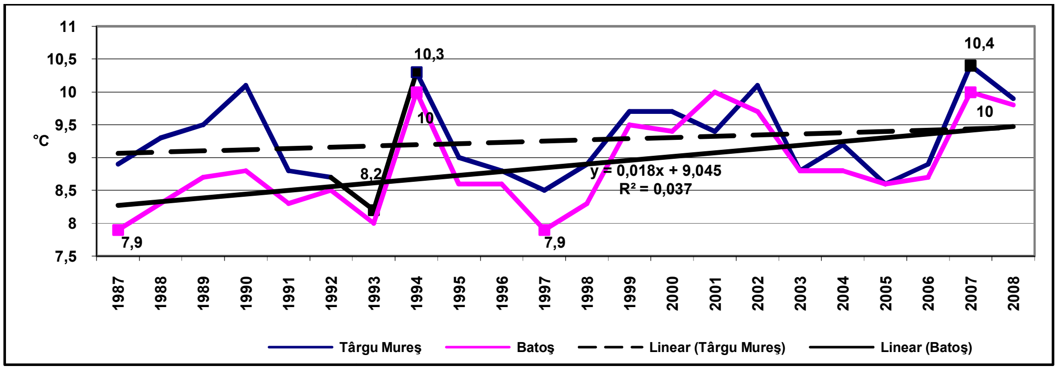
2.1.3.1.5. The exposure of the slopes

The exposure of the slopes to the received solar radiation determines an uneven distribution of the amount of energy, which together with slope and slope shape define the caloric regime of the place, the precipitation regime, the distribution and the type of soil and vegetation and the use of the land, all with implications in the unfolding of the slope processes.

2.1.4. Climate

2.1.4.1.1.The average annual temperature

Multiannual average temperatures, calculated on the basis of the values recorded at the Târgu Mureş and Batoş meteorological stations for the period of 1987-2008, recorded a decrease from the Mureş Corridor (9.2°C in Târgu Mureş) to the sub-carpathian area (8.9°C In Batoş), according to altitudes increasing.

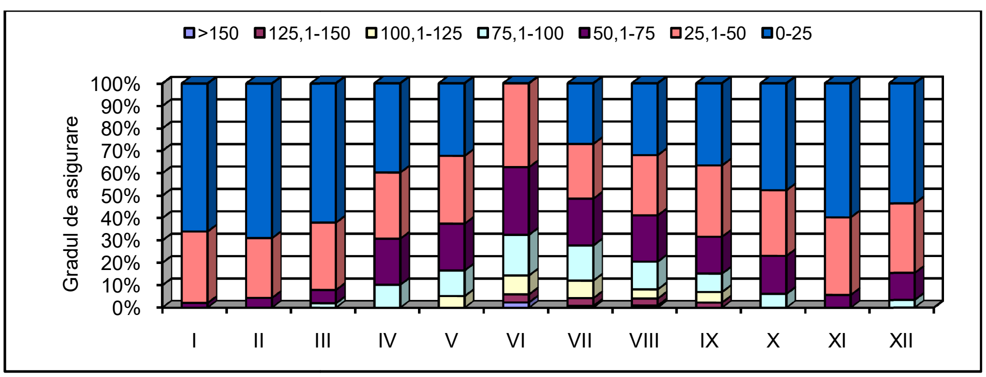


Variation of annual average temperatures

In the analysed range, the mean annual amplitude values generally showed oscillations between 21.4°C -26.6°C in Târgu Mureş and between 20 ° C -24 ° C at Batoș.

2.1.4.2.1. Variations of annual rainfall

In the Mureş Corridor and Batoş Hills, the highest frequencies record the rainfall ranges between 501-600 mm/year and the highest degree of insurance have the rainfall ranges between 401-450 mm/year and 45-500 mm/year.



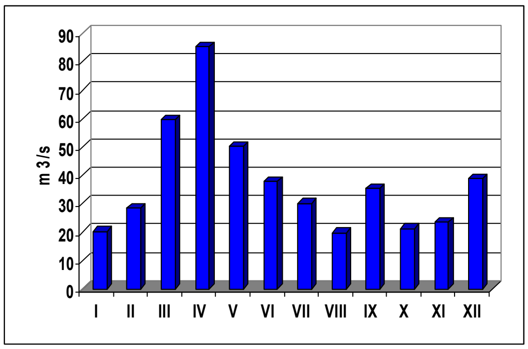
The monthly precipitation assurance, Târgu Mureş 1978-2008

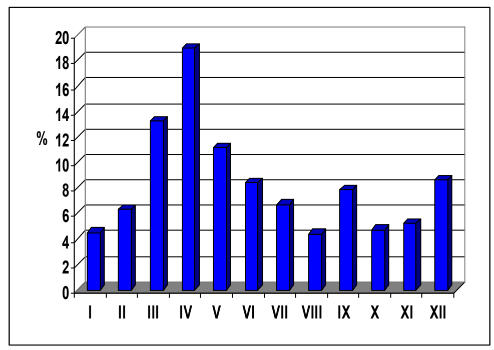
At Eremitu, the highest frequency records precipitation between951-1000 mm/year,followed by intervals between 751-800 and 851-900 mm/year, representing a share of 19.4% respectively 16.1% of the analyzed years.

2.1.5. Hydrography

The hydrographic system is represented by the tributaries of the Mureş River, which is the main drainage axis of the Reghin Hills, having as main tributary the Gurghiu River.

Multi-annual average flow of the Mures River at the Glodeni hydrometric station,in the period 1990-2010, it was 38.3 m^3/s with a maximum monthly in april, 85.3 m^3 s and the minimum in august 19.8 m^3/s.At the Ibaneşti hydrometric station, for the same interval, the Gurghiu River records a multiannual average flow rate of 7.8 m^3/s, with a monthly maximum in april of 20.3 m^3/s and the minimum in october of 4.7 m^3/s.





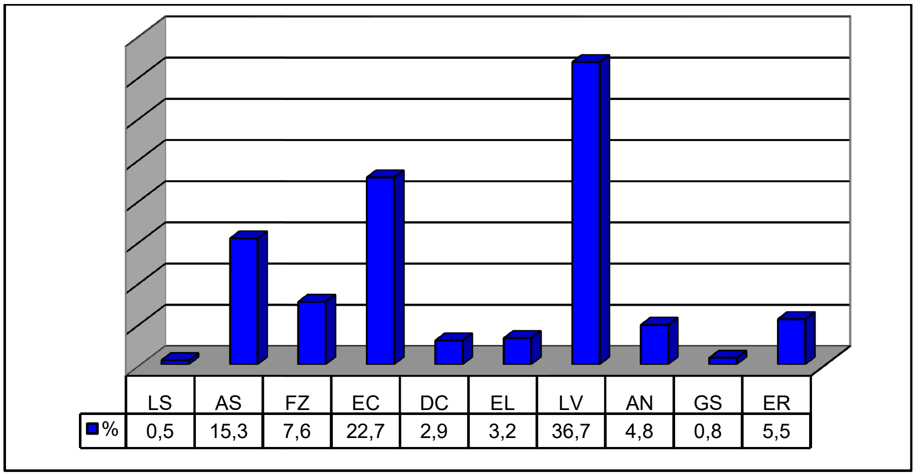
Monthly average flow of the Mureş River at Glodeni (1990-2010)

2.1.6. Vegetation

As a result of the uniformity of the relief, the vegetation of the Reghin Hills is characterized by an alternation of the forest areas with the meadows.

2.1.7. Soils

According to the Romanian Soil Taxonomy System adopted in 2003, in the Reghin Hills were identified 16 taxonomic units of soils belongs to 10 sub-types of the protisols, cernisols, cambisols, luvisols, andisols, hidrisols and antrisols.



Share of the main types of soils

2.2. Anthropic premise

Anthropogenic activities are a source of change in the state of the environment through different forms of impact. Human pressure on land can generate imbalances in the morphogenetic system with direct influences on the dynamics of geomorphological processes manifestations.

3. CLIMATE HAZARDS IN THE REGHIN HILLS

3.1. Heat waves and cold waves

The study of the thermal regime was based on the following criteria:Analysis of annual average temperature deviations from the multiannual average;average monthly temperature variation in January and July;time frequency by the Hellman criterion;the absolute extreme temperature values;frequency of days with different characteristic temperatures (number of cold nights with minimum temperatures ≤ -10°C, number of days with maximum temperatures ≤ 0°C, number of days with minimum temperatures ≤ 0°C, number of days with maximum temperatures ≥ 25°C, number of days with maximum temperatures ≥ 30°C) .

• From the analysis of the thermal character of the years according to the Hellman criterion, we observe a decrease of normal thermal years' frequency (68,2% Târgu Mureș, 54,5% Batoș), and an increase of cool years (9,1% Târgu Mureș, 27,3% Batoș), from area's western part to main subcarpathian hilly area.

• January is considered the coldest year month, with a multiannual monthly average temperature of -2,3°C at both analyzed stations.

• July is the year's hottest month, with a multiannual monthly average temperature of 20,7°C at Târgu Mureș and 19,7°C at Batoș..

• The lowest air's absolute temperature values in our area between 1987- 2008 were -24,5°C in January 2006, February 1987 and December 2001 at Târgu Mureș Station, and +26,2°C in January 1987 at Batoș Station.

3.3. Excess of humidity

The following were analyzed:

- Positive deviation of annual average rainfall from the multiannual average;
-The pluwometric excess analysis using the Angot Index;
-The frequency of periods with a pluviometric excess using the Hellman criterion;
-Analysis of pluviometric excess using the Standardized Anomaly of Precipitation method;
- Evaluation of pluvial aggressionusing the Fournier Index;

• From the analysis of the deviations values of the annual average quantities of rainfall over the multiannual average, it can be seen that both the values and the frequency of the positive deviations show an increase from the Mureş Corridor to the submontane area.

• For years we've been analyzingthe Angot Index recorded values between 2.0-2.5 in June, in 29% of cases in Gurghiu, 22.7% in Batoş, 16.1% in Târgu Mureş and 12.9% of cases at Eremitu and values above 2.5 had a frequency ranging between 3.2% and 9.1% of cases.

• Summing the frequency of pluviometric excess periods with different characteristics after Hellman criterion, we can see the high share of excessly rainy periods (39.4-51.8%) in each season, especially in the autumn, followed by the very rainy (19.2-27.1), the rainy and moderately rainy weather having the lowest weights in all cases by 13.7-24% respectively 12.2-17.44% of the total cases.

• Multiannual average valuescalculated on the Fournier Index,for the analyzed ranges were 21.5 mm at Târgu Mureş station, 24.7 mm at Batoş, 25.5 mm at Gurghiu and 32.8 mm at Eremitu, values witch indicate a low rainfall aggressiveness for entire analyzedarea.

3.5. The hail

• The possible period of occurrence of the hail phenomenon is between March and October, with the maximum frequency at the end of spring and early summer.

• The analysis of the monthly hailfall frequency shows for the analyzed period the highest probability of production of this phenomenon in May and June and the lowest probability in March.

3.6. The fog

• The highest average of monthly number days with fog is recorded in January, 4.0-11.3 days per month and in December, 3.6-9.1 days per month,values witch indicating a frequency of 19.0-22.4% and 18.8-21% of the total number of cases in a year.

3.7. The hoar frost

• In Reghin Hills, the first autumn frost is recorded on average in the second decade of October in the Mureş Corridor and in Batoş Hills and in the first decade of the month in the submontane area.

• The multiannual average number of days wit hoar frost in the Reghin Hills varies between 22-47.3 days, but this shows spatio-temporal variations.

4. GEOMORPHOLOGICAL HAZARDS AND RISKS IN THE REGHIN HILLS

4.1. Geomorphological processes that associate risk in the Reghin Hills

The main geomorphological processes with risk potential that occur in the analyzed area can be grouped in *fluvial processes* (deep erosion, lateral erosion, accumulation) and *slope processes*. Slope processes can be classified into *gravitational processes* (landslides) and*hydrological slope processes* (linear and areolar erosion processes).

Fluvial processes are highlighted by both lateral and deep erosion as well as through accumulation processes. They are most active at the beginning of spring, when snow melting overlaps with spring rains,which generates significant increases in flows.

Shore landfall– Brâncoveneşti

Landslides are the most widespread form of mass movements and are recorded as a distinct note in the Reghin Hills landscape in a wide range of shapes with a wide spread in the Teleac Hills, Batoş and Monor Hills.

Ladslide– Teleac Hills

Superficial landslides have the highest frequency in the upper half of slopes with slopes above 5-10 ° and are most active in the spring months - March to April.Superficial landslides affect the upper part of the soil to less than 1 m deep and are impressed by small,and are imposed in relief by small,chaotically disposedfurrows.

The lenticular slides have a wide spread, being generally caused by humidty excess.The area of detachment is poorly highlighted,with heights between 0.5-1 m and the sliding body, whose lengths rarely exceed 100 m and widths of 50 m,is imposed in the relief of the slopes by small thresholds given by short, lenticular, stepped waves.

Lenticular slides – Ilioara

Erosion by concentrated currents. The largest areas affected by linear erosion meet in the Teleac Hills, on the slopes of the Gurghiu, Habic, Chiher, Teleac and Călușer valleys,where lack of prevention and combat facilities associated withunreasonable land use has favored the acceleration of these processes.

Gully system – Idicel Pădure

Gully sysem – Idicel Pădure

Areolar erosion by pluviodenudation and surface erosion determines washing of the top layer of soil, decreasing the amount of humus and nutrients in the soil resulting a land degradation and reduction of productive potential of agricultural areas.

4.2. Analysis and assessment of geomorphological hazards in the Reghin Hills

4.2.1. Susceptibility of slopes to landslides

Data used to analyze the susceptibility of the slopes were derived from the digital terrain elevation model (slope inclination, density of fragmentation, depth of fragmentation, slope exposition), maps (geographic map, geological map, soil map) and Corine Land Cover 2006 (vegetation and land use). By weighted superposition of factorial maps we obtained four classes of susceptibility.

•**Very low susceptibility** - characterizes the central sector of the analyzed area dominated by the Mureș Corridor, the Gurghiului Valley and the terraces of the valleys;

•**Low susceptibility** - areas with low susceptibility generally overlap with the contact areas between the slop and valleys (glacis), and the alluvial cones;

•**Medium susceptibility** - generally overlap surfaces affected by superficial landslides and recent landslides in the process of stabilization;

•**High susceptibility** - overlap with areas affected by active landslides or with reactivation potential.Such areas have been identified along the secondary valleys and on the administrative territory of the localities Dumbrava, Monor, Batoş, Idicel, Idicel Padure, Adrian, Orşova, Petrilaca de Mureş, Teleac and Padureni.

4.2.2. Susceptibility of land to surface erosion

The highest effective erosion values over 1 t /ha/year generally characterize the upper third of the concave slopes,slopes without vegetation, strongly affected by erosion processes (areolar, linear erosion).

4.2.3. Vulnerability of the population to geomorphological hazards

In our study, in order to analyze the vulnerability of the population of the Reghin Hills to the current geomorphological processes, the indicators taken into account were grouped into *demographic and human indicators* (demographic potential, population dynamics, population structure by age groups, age) and *spatial indicators* (demographic size of settlements, density of settlements, coefficient of settlements area, dispersion index of settlements, land use pattern and road network).

4.2.3.1. Analysis of elements exposed to risk

4.2.3.2. Vulnerability analysis

The analysis of the results shows that, depending on the share of the female population, of the total of 75 settlements,which overlap the analyzed area, a high vulnerability record 14 settlements (18.4%), spread predominantly in the sub-mountainous area.The Demographic Aging Index highlights a high vulnerability for 34 settlements, representing a share of 44.7% of all settlements.

The analysis of the resulting map shows that,in relation to the current geomorphological processes, a very large and large vulnerability records the settlements and the road infrastructureoverlapping to secondary valleys, which fragment the subcarpathian area, contact glacies and slopes with high morphodynamic potential, which have a high susceptibility to landslides and to active linear erosion processes.

4.2.4. Risk assessment induced by geomorphological processes in the Reghin Hills

To the highest degree of risk are exposed the settlements located along the secondary valleys(Idicel, Păuloaia, Chiheru de Jos, Nadăşa, Ursiu de Jos, Căcuciu and Şerbeni) and the settlements located in the depression basins (Săcalu de Pădure, Padureni, Glăjărie), where the settlements are characterized by the arrangement of households along a main axis, which tracks the watercourse, with a large distribution of households on alluvial cones and slopes, imposed by the lack of space and the frequency of overflows.

Higher terraces offer the most favorable habitat conditions, being exposed to the geomorphological risk only the sectors with high fragmentation from the secondary hydrographic network or torrential organisms are exposed.

5. MEASURES TO MITIGATE AND PREVENT THE EFFECTS OF CLIMATIC HAZARDS AND GEOMORPHOLOGICAL RISKS

5.1.Measures to mitigate and prevent the effects of climatic hazards

5.1.1.Measures to prevent the effect of hail

Among the active methods in the prevention of hail , the most effective method is the seeding of cumulonimbus clouds with different chemical substances (usually silver iodide, potassium iodide or carbon snow) by terrestrial generators, aviation, artillery and anti-hail rockets.

5.1.2.Measures to prevent and mitigate the effects of fog

- heating the near surface air;

- scattering hygroscopic substances in fog in order to absorb the droplets;

- seeding the fog with solid carbon dioxide with supercooled droplets below -4C to create precipitation;

5.1.3. Measures to prevent and mitigate the effects of frost and hoarfrost

• Practical measures before planting or sowing

• Measures aiming the attenuation of nocturnal radiation,

• Measures for increasing the soil and air temperature

• Measures to prevent the formation of air thermal inversion in the layer beneath the soil

5.1.4. Measures to prevent and mitigate the effects of rime deposition

- preventive heating of the conductors by providing a powerful movement which prevents their cooling below 0°C;

- the installation of rime alarm signal;

5.1.5. Measures to prevent and mitigate the effects of blizzard

- preparing early the intervention equipment;

- providing food and water supplies;

- predicting the weather as accurate as possible;

5.2. Measures to mitigate and prevent the effects of geomorphological risks

5.2.1. **Measures to mitigate and prevent the mass movement process**

- specific agro- and hydro -technical works ensuring a specific drainage which eliminate or mitigate leakage thus softening the intensity of erosion in depth;
- to avoid overloading the landslide-susceptible slopes with constructions or plantation;

5.2.2. Measures to mitigate and prevent the effects of rain erosion

• Silvotechnical works;

• Agrotechnical works;

• Hydrotechnical works;

5.2.3.Measures to mitigate and prevent the effects of soil erosion

-the system of works in the direction of the level curves;

- anti-erosional organizational system by using stripes culture;

- terraced slopes;

- hydrotechnical works;

CONCLUSIONS

Extreme manifestations of climatic phenomena often bring material and financial damages, especially in agriculture, but can cause significant damages indirectly and in other economic branches. With regard to the vulnerability of elements that may be affected by a certain type of risk, they can be multiple: civil engineering, water and gas supply networks, transport infrastructure, electric cables, etc.

The analysis of factors influencing climatic hazards and geomorphological risks in the studied area highlights areas that may be affected by one or more of them.

Multiannual average temperatures, calculated on the basis of the values recorded at the Târgu Mureş and Batoş meteorological stations for the period 1987-2008, recorded a decrease from the Mureş Corridor (9.2°C) to the actual sub-Carpathian area (8.9°C), according to increasing altitudes.

While at the western limit of the studied area the average annual precipitation amounts are between 500-600 mm, in the eastern extremity, at the contact with the mountain area, the values are between 700-900 mm. The highest frequencies, with an insurance level of 81.9%, record the rainfall ranges between 501-600 mm year.

The average multi-annual wind speedin the studied area records low values ranging from 1.2 m/s to 1.5 m/s. The analysis of the average wind speeds in directions shows the highest speeds for winds blowing from the Northwestern and Western sector (March-April) with average values between 2.4-2.9 m/s respectively 2,5-2,9 m/s.

The vulnerability of a territory to hail is conditioned by the average number and the maximum annual number of days with hail and by the intensity of the precipitation. The possible period of the production of hail phenomenon is in the range of March to October, with maximum frequency at the end of spring and early summer, with most hail days recorded in May and June, with a monthly multiannual average of 0,3-0,4 days.

The annual number of foggy days varied from year to year, with the number of fog days generally ranging from 30-60 days per year to Târgu Mureş, between 10-30 days a year in Batoş and between 10-20 Days per year at Eremitu and Gurghiu.

In the Reghin Hills, the first autumn frost is recorded on average in the second decade of October in the Mureş Corridor and in the Batoş Hills and in the first decade of the month in the submontane area, the average multiannual number of days with frost were between 22-47.3 days. The earliest frosts were recorded in the first part of September (5.09-12.09), and the latest in the first part of May (6.05-12.05).

Geomorphological processes are in direct relation to the spatio-temporal manifestation of climatic elements and phenomena, including air temperature, atmospheric precipitation and the air mass dynamic with a major role.

Among the geomorphological processes with potential risk in the analyzed area, landslides are a distinct note in the landscape of the Reghin Hills in a wide range of forms, with a wide spread in the Teleac Hills, Batoş and Monor Hills.

Fluvial processes are evidenced both by lateral erosion and deep erosion. The erosion of the banks is very active along Mureş between Vălenii de Mureş and Brâncoveneşti and Petelea and Gorneşti localities, where after the artificial modification of the river course, long segments of the shore were subjected to lateral erosion.

Concentrated flow erosion through the forms created with the areolar erosion leads to the advanced degradation of the slopes with more delicate anti-erosion treatment problems. The average values of the soil erosion rate in the analyzed area are between 0 and 1.2 t/ha/year, the highest values being generally recorded in the upper third of the concave, vegetation-free slopes, strongly affected both by processes of surface erosion and by erosion through concentrated leakage.

Areas with high and large geomorphological risk have a weight of 3.6% and 12.2% of the total area analyzed and are characterized by a high morphodynamic potential, with slopes affected by erosion processes (linear and areolar) and landslides with reactivation potential.

At the highest risk of floods and reversals are exposed the windmill settlements in the meadow and on the lower terraces of Mureş and along the secondary valleys (Idicel, Păuloaia, Chiheru de Jos, Nadăşa, Urisiu de Jos, Căcuciu, Şerbeni).

Areas with medium geomorphological risk have a share of 27.2% of the total area and are generally represented by pastures and agricultural land overlapping slopes with slopes between 15-20°, susceptible to superficial landslides and to linear and areolar erosion processes.

Regarding measures to reduce vulnerability, even if there is an institutional preparation and the access to projects is very easy, the weak involvement of the authorities and the population make this area free of funding to support its sustainable development and to lead to the reduction of vulnerability.

SELECTIVE BIBLIOGRAPHY

1. **Arnoldus, H.M.,** (1980), *"An approximation of the rainfall factor in the Universal Soil Loss Equation."* în Assessments of Erosion, edited by De M. Boodts, D. Gabriels, 127-132. Chichester: John Wiley and Sons Ltd
2. **Alleotti, P., Baldelli, P., Govi, M.,Polloni, G., Puma, F., Villani, B.,** (1999), *Hazard and risk assesment in the Po river Bassin (Nort Italy)* (https://www.researchgate.net/publication/45514732)_
3. **Bălteanu, D.** (2004), *Hazardele naturale şi dezvoltarea durabilă*, Revista geografică, Inst. Geogr., X, 3-6.
4. **Bilaşco, Șt,.** (2008), *Implementarea G.I.S. în modelarea viiturilor de versant*, Editura Casa Cărţii de Ştiinţă, Cluj-Napoca.
5. **Bilaşco, St.,** (2009), *Implementation of the USLE model using GIS techniques. Case study the Someşan Plateau*, în Carpathian Journal of Earth and Environmental Sciences, vol 4., no.2, p. 123-132.
6. **Birkmann, J.** (2006), *Indicators and criteria for measuring vulnerability: theoretical basis and requirements.* In: Birkmann J, (ed.). Measuring vulnerability to natural hazards Towards disaster resilient societies. Tokyo: United Nations University; (2006), pp. 55-77.
7. **Blaikie, P.,Cannon, T., Davis, I., Wisner, B.,** (1994), *Natural Hazards, peple's vulnerability, and disasters.* Routlege, London and New York, p.284.
8. **Brabb, E.E.,** (1984), *Inovative Approches to Landslide Hazard and risk mapping*, Intern. Sypos on landslides, Toronto.
9. **Brooks, N., Adger, W.N., Kelly, P.M.,** (2005), *The determinants of vulnerability and adaptive capacity at the national level and the implications for adaptation*, Global Enviromental Change, 15, pp. 151-163.
10. **Carreño, M-L, Cardona, O, & Barbat, A.**, (2007) *Urban Seismic Risk Evaluation: A Holistic Approach. Natural Hazards* , 40(1), pp. 137-172.
11. **Carson, M.A.,Kirby M.J.,** (1972), *Hillslope Form and process*, Univ. Press, Cambridge.
12. **Croitoru, Adina Eliza, Gherman, T.C.,** (2002), *Situații sinoptice care au generatluni excedentare pluviometric în regiunea de nord-vest a României,* Studia Universitatis, „Babeş-Bolyai", Seria Geographia, , p.25-32.

13. **Croitoru, Adina Eliza,** (2006), *Excesul de precipitații din Depresiunea Transilvaniei*, Editura Casa Cărții de Știință, Cluj-Napoca.
14. **Cutter, L., Susan.,** (1996), *Vunerability to Enviromental Hazards*, în Progress in Human Geography, 20, 4, pp. 529-539.
15. **Cutter, L., Susan.,** (2001), American Hazardscapes. The Regionalization of Hazards and Dizasters, Joseph Henry Press, Washington D.C., pp. 1-12.
16. **Dwyer, A., Zopou, C., Nielsen, O., S.,Roberts, S.,** (2004), *Quantifying Social Vulnerability: A methodology for idetifying those at risk to natural hazards,* Geoscience Australia Record 2004/14, pp. 92
17. **Gârbacea, V.,** (1963), *Depresiunea Deda-Porceşti*, Extras din Probleme de geografie, vol IX, Bucureşti.
18. **Gârbacea, V.,** (2015), *Dealurile Bistriței și Gurghiului. Studiu geomorfologic*, Editura Casa Cărții de Știință, Cluj-Napoca.
19. **Goţiu, Dana, Surdeanu, V.,** (2007), *Noţiuni fundamentale în studiul hazardelor naturale*, Presa Universitară Clujeană, Cluj-Napoca.
20. **Goţiu, Dana, Surdeanu, V.,** (2008), *Hazardele naturale şi riscurile asociate din Ţara Haţegului*, Presa Universitară Clujeană, Cluj-Napoca.
21. **Grecu, Florina,** (2009), *Hazarde şi riscuri naturale,* ediţia a IV-a,Editura Universitară, Bucureşti.
22. **Guzzetti, F., Carrara A., Cardinali M. & Reichenbach P.,** (1999), *Landslide hazard evaluation: an aid to a sustainable development*. Geomorphology, 31, 1999, 181-216. (http://www.uib.cat /depart/Guzzetti.pdf.)
23. **Guzetti, F.**, (2000), *Landslide fatalities and the evaluation of landslide risk in Italy, în Engineering Geology*, nr. 58, pp. 89-107
24. **Holobâcă I.H., Croitoru Adina Eliza, Vajda Claaudia Andrea,** (2001), *Considerații asupra variației regimului precipitațiilor în Depresiunea Transilvaniei,* Studia Universitatis, „Babeș-Bolyai”, Seria Geographia, 1, p.33-39.
25. **Ianoş, I.,** (1994), *Riscul în sistemele geografice*, studii şi Cercetări de Geografie, XLI, Bucureşti.
26. **Ianoş, I.**, (2000), *Sisteme teritoriale. O abordare geografică*, Editura Tehnică, Bucureşti.
27. **Irimuş, I. A.,** (1997),*Cartografiere geomorfologică*, Ed. Focul Viu,ISBN 973-95758-5-4,Cluj-N., p.112.

28. **Irimuş, I.A**., (1998), *Relieful pe domuri şi cute diapire în Depresiunea Transilvaniei*, Editura Presa Universitară Clujeană, ISBN 973-9354-55-6, Cluj-Napoca, p.299.
29. **Irimuş, I.A.**, (2002), *Riscuri geomorfice în regiunea de contact interjudeţeană din Nord-Vestul României*, în Riscuri şi Catastrofe, vol I, Editura Casa Cărţii de Ştiinţă, Cluj-Napoca.
30. **Irimuş, I.A.,** (2003) *Riscuri geomorfice în regiunea de contact interjudeţeană din nord-vestul României,* în Riscuri şi catastrofe, vol. I, Editura Casa Cărţii de Ştiinţă, Cluj Napoca.
31. **Irimuş I.A.,** (2003), *Geografia Fizică a României*, Editura Casa Cărţii de Stiinţă, Cluj-Napoca, ISBN 973-686-352-3, p.250.
32. **Irimuş, I.A.**, (2003), *Tehnici de cartografiere*, Edit. Facultăţii Dimitrie Cantemir, Târgu-Mureş.
33. **Irimuş, I.A., Vescan, I., Man, T.,** (2005), *Tehnici de cartografiere, monitoring şi analiză GIS*, Editura Casa Cărţii de Ştiinţă, Cluj Napoca.
34. **Irimuş, I.A, Szilágyi, J.** (2013), *Considerations on the termal conditions in the Reghin Hills.* Rev. Riscuri şi Catastrofe, an XII, vol.12, nr.1/2013, p.66-77, ISSN 1584-5273, Ed.Casa Cărţii de Ştiinţă, Cluj-Napoca.
35. **Klein, J.T., Robert, J., Nichols, F. Th.,** (2003), *Resilience tonatural hazards: how to useful is this concept?*, in Enviromental Hazards, 5(2003), pp.35-45.
36. **Lambert, R., Lami, J.M., Senges, F.,** (1990), *La sécheresse de 1989 dans le bassin de la Garonne*. Université Toulouse – Mirail, Institut de Géographie, 75 p.
37. **Mac, I., Petrea, D.**, (2003), *Polisemia evenimentelor geografice extreme*, în Riscuri şi catastrofe, vol. I, Editor V. Sorocovschi, Editura Casa Cărţii de Ştiinţă, Cluj Napoca.
38. **Mac, I., Petrea D.,** (2003), *Sisteme geografice de risc*, în Riscuri şi catastrofe, vol. II, Editor V. Sorocovschi, Editura Casa Cărţii de Ştiinţă, Cluj Napoca.
39. **Măhăra, Gh., Gaceu, O.,** (2005).*Depunerile de gheaţă din munţii Bihor-Vlădeasa şi impactul lor asupra mediului înconjurător*, în Riscuri şi catastrofe, an. V, nr.4. 260-272.
40. **Makkai, G.,** (2003), *Az erdélyi mezőség tájökológiája*, Mentor Kiadó, Marosvásárhely.
41. **Mckee, T. B., Doesken, N. J., Kleist, J.**, (1993), *The relationship of drought frequency and duration to time scales*, Preprints, 8th Conference on Applied Climatology, 17-22 January, Anaheim, CA.
42. **Moldovan, F.,** (2003), *Fenomene climatice de risc*, Editura Echinox, Cluj Napoca.
43. **Morse, S.**, (2004), *Indices and indicators in development: an unhelthy obsesions with numbers?*, Earthscan, London, Sterling, VA.

44. **Moţoc, M.,** (1963), *Eroziunea solului pe terenurile agricole şi combaterea ei,* Editura Agro-silvică, Bucureşti.

45. **Mutihac, V., Strautulat, Maria-Iuliana, Fechet, Roxana-Magdalena**, (2007), *Geologia României*, Editura Didactică şi Pedagogică, R.A., Bucureşti.

46. **Peguy, Ch. P.,** (1992), *Les risques naturales majeurs*, în Encyclopédie de Géographie, Ed. Economica, Paris, pp. 937-948.

47. **Petrea, D.,** (1998), *Pragurile de substanță, energie și informație în sistemele geografice*, Editura Universității din Oradea, Oradea.

48. **Rădoane, Maria, Ichim, I., Rădoane, N., Surdeanu, V.,** (1999), *Ravenele. Forme, procese, şi evoluţie*, Presa Universitară Clujeană, Cluj-Napoca.

49. **Schröter, D.** (2005), *Vulnerability to changes in ecosystem services*. CID Graduate Student and Postdoctoral Fellow Working Paper

50. **Schröter, D. C.,Coryn, C. L. S., Noakes, L. A., Westine, C. D.,** (2011), *A systematic review of theory-driven evaluation practice from 1990 to 2009*. *American Journal of Evaluation*, *32*(2), pp.199-226.

51. **Sfâriac, I.,** (1966), *Hidrogeologia Jabeniţei*, în revista Comunicări de Geografie, vol.VI.

52. **Simone, Sterlacchini,** (2011), *Vulnerability Assessment: concepts, definitions and methods*, National Research Council of Italy, Institute for the Dynamic of Environmental Processes , Milan (Italy).

53. **Smith, K.,** (1992), *Enviromental Hazards-Assessing Risk and Reducing Disaster*, London; New York:Rutledge.

54. **Sorocovschi,V.,**(2003), *Complexitatea teritorială a riscurilor şi catastrofelor*, în „Riscuri şi catastrofe”, vol.II, Edit.Casa Cărţii de Ştiinţă, Cluj Napoca.

55. **Sorocovschi, V., Mac, I.,** (2004), *Percepţia enviromentală şi răspunsurile umane faţă de risc,* , în „Riscuri şi catastrofe”, Nr.I., Editura .Casa Cărţii de Ştiinţă, Cluj Napoca.

56. **Sorocovschi, V.,** (2004), *Studiul fenomenelor de uscăciune şi secetă în Câmpia Transilvaniei*, Studia Univ. „BabeşBolyai”, Geografie, 1, XLVII, Cluj-Napoca, p. 25-32.

57. **Sorocovschi, V.,** (2005), *Prevenirea riscurilor naturale,* în Riscuri şi catastrofe, an. IV, nr.2, Editura Casa Cărţii de Ştiinţă, Cluj Napoca.

58. **Surd, V.,** (2001), *Geodemografie*, Editura Presa Universitară Clujeană, Cluj-Napoca.

59. **Surdeanu, V.,** (1998), *Geografia terenurilor degradate - Alunecările de teren*, Editura Presa Universitară Clujeană, Cluj-Napoca.

60. **Surdeanu,V., Rus, I., Irimuş, I.A., Petrea, D., Cocean, P**., (2009), *Rainfall influence on landslide dynamics* (Carpathian Flysch Area, Romania), Geografia Fisica e Dinamica Quaternaria, vol.32(1) / 2009, p. 89-95.
61. **Szilágyi, J.,** (2009), *Potențialul demografic al Municipiului Reghin și al zonei periurbane,* în volumul Simpozionului Internaţional Geografia în Contextul Dezvoltării Contemporane,pp.183-197, Presa Universitară Clujeană, Cluj-Napoca.
62. **Szilágyi, J.,** (2009), *Impactul turismului asupra mediului în Stațiunea balneoclimaterică Sovata,* în volumul Simpozionului Internaţional Geografia în Contextul Dezvoltării Contemporane,pp.277-289, Presa Universitară Clujeană, Cluj-Napoca.
63. **Szilágyi, J.,** (2011), *Fenomenul de brumă și riscurile asociate în Dealurile Reghinului*, în volumul Simpozionului Național al SGR, Geografia şi Societatea Umană, Baia Mare.
64. **Szilágyi, J., Irimuş, I. A.** (2012) *The Deficit of Humidity and the Associated Risks in the Reghin Hills* înStudia Universitas Babeş-Bolyai, Geographia 2, anul LVII, p.81-91, Ed. Cluj University Press, ISSN: 1221-079X, Cluj-Napoca.
65. **Szilágyi, J.,** (2012), *Frecvența și intensitatea inversiunilor termice în Subcarpații Reghinului*, în GEIS, Vol. XV, pp.58-63, ISSN-1841-9941, Editura CCD, Deva.
66. **Szilágyi, J.,** (2012), *Presiunea umană asupra terenurilor agricole în Dealurile Reghinului*, în GEIS, Vol. XVI, pp.105-110, ISBN-978-606-93300-3-6, Editura Karina, Deva.
67. **Szilágyi, J., Irimuş, I.A,** (2013), *The excess of Humidity and its associated Risks in the Reghin Hills*. Rev. Riscuri şi Catastrofe, an XII,vol.12,nr.1/2013, p.89-99, ISSN 1584-5273, Ed.Casa Cărţii de Ştiinţă, Cluj-Napoca.
68. **Szilágyi, J.,** (2013), *Gindina, fenomen climatic de risc în Dealurile Reghinului*, în volumul Simpozionului Național al SGR, Geografia-Știința a Întregului Teritorial, pp.181-187, Editura Eurobit, Timișoara.
69. **Szilágyi, Emilia, Szilágyi, J.,** (2014), *Strategii de amenajare turistică în Defileul Mureșului între Toplița și Deda*, în GEIS, Vol. XVIII, pp.133-138, ISSN-1841-9941, Editura CCD, Deva.
70. **Szilágyi, J., Irimuş, I.A (2014),***The Risks associated to the Hoarfrost Phenomenon in the Reghin Hills.* Rev. Riscuri şi Catastrofe, an XIII,vol.15, nr.2/2014, p.80-89, ISSN 1584-5273, Ed.Casa Cărţii de Ştiinţă, Cluj-Napoca.
71. **Szilágyi, J.,** (2016), *Aspecte privind distribuția spațială al așezărilor din Dealurile Reghinului*, în GEIS, Vol. XX, pp.137-142, ISSN-1841-9941, Editura CCD, Deva.

72. **Szilágyi, J., Irimuş,I. A, Rus, Mădălina, Cioban,T**. (2016), *Evaluation of Soil Erosion in Reghin Hills using the USLE Method*. Rev. Riscuri și Catastrofe, nr.XV,vol.18.,nr.1,p.91-99,.ISSN 1584 -5273.
73. **Szilágyi, J., Irimuş, I. A, Togănel**, **C., Emilia Szilagyi** (2016), *Rainfall Aggressiveness Evaluation in Reghin Hills using Fournier Index.* Rev. Riscuri și Catastrofe,.nr.XV,vol.18.,nr.1,p.83-89,.ISSN 1584 -5273.
74. **Szilágyi, J.,** (2016), *Procese geomorfologice cu potențial de risc în Dealurile Reghinului*, în GEIS, Vol. XX, pp.27-32, ISSN-1841-9941, Editura CCD, Deva.
75. **Szilágyi, J., Irimuş,** (2017), *The vulnerability of the population to geomorphological hazards in the Reghin Hills*,Rev. Riscuri și Catastrofe,.nr.XVI,vol.20.,nr.1,.ISSN 1584 -5273.
76. **Thywissen, Katharina,** (2006), *Components of Risk. A comparative glossary*, Studies of the University: Research, Counsel, Education - Publication Series of UNU-EHS, No.2/2006, Bonn, Germany.
77. **Topor, N.**, (1958), *Bruma și înghețul. Prevederea și prevenirea lor*, Editura Agrosilvică, București.
78. **Treveek, J.,** (1999), *Ecological impact assessment*, Blackwel Science, Oxford.
79. **Treweek, J.,** (2006), *Ecological impact assessment*, Institute of Terrestrial Ecology, Monks Wood Komex Clarke Bond, Bristol.
80. **Varnes D. J.,** (1984), *Landslide hazard zonation: a rewiew of principles and practice,* Pblicaion de l′ UNESCO, Paris, Natural Hazards, pp. 9-63 (http://unesdoc.unesco.org/images/0006/000630/063038EB.pdf).
81. **Wischmeier, W.M., Smith, D.D.,** (1978), *Predicting rainfall erosion losses*, Supersedes Agriculture Handbook, no. 282.
82. **Wisner, B. Blaikie, P.,** (2004), *Assessment of the Economic Impact of Natural and Man Made Disasters*. Expert Consultations on Methodologies, Brussels.
83. **Vogel, C, Brien,** (2004) *Vulnerability. and global environmental change: rhetoric and reality*. Aviso: An Information Bulletin on Global Environmental Change and Human Security., 2004, 1-8.
84. **Wischmeier W.H., and Smith D.D.,** (1978) *Predicting rainfall erosion losses: A guide to conservation planning* . USDA Agriculture Handbook 537.
85. **Zamfir, Gh.,** (1975), *Poluarea mediului ambient*, Editura Junimea, Bucureşti

86. **Zăvoianu, I., Dragomirescu, S.,** (1994), *Asupra terminologiei folosite în studiul fenomenelor naturale extreme*, Studii şi Cercetări de Geografie, t.XLI, pp. 59-65.