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IDENTIFICATION AND ANALYSIS OF THE GEOMORPHIC, CLIMATIC AND HYDROLOGICAL HAZARDS FROM BAIA MARE MUNICIPALITY

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ABSTRACT

INTRODUCTION

Almost one century ago, Simion Mehedinţi, in „Terra – introducere în geografie ca ştiinţă”, saw the Earth as a complex system characterized by causal interaction and hierarchy, where the human being represents one of the most active geographical agents in the natural components' dynamic and modification.

This paper aims to investigate specific natural hazards from Baia Mare municipality, a geographical space over which the pressure of the anthropic factor has special valence. The applied context of the performed geographical analysis imposed the correlation of notions, concepts, methodology and legalities, specific to geography, with the national administrative and economical legislation' requests and norms, both in conformity with the European Union's provisions. On this note, the elaboration was quite difficult, the respective methodologies not yet being unitary; where it was possible, the cartographic and tabular material's analysis was made through the modules of ArcGis 9.2 package and other professional software.

Besides the study and critical undertaking of the existing documentation (bibliography, maps and special plans – topographic, geological, seismic, climatic, geotechnical), the research was based on my own investigations in the field, mapping, topo elevations, small and average depth soil logs, geotechnical analysis etc. Depending on the analyzed geographic area' particularities and on the performed analysis' conclusions, rehabilitation proposals of the local malfunctions were made.

PART ONE: GENERAL NOTIONS

General aspects concerning the paper's goal and structure, methodological aspects, geographical location, geological and biopedogeographic cover's features, as well as those geotechnical from the Baia Mare municipality's urban area.

CHAPTER 1
CONCEPTUAL ASPECTS

1.1. Paper's goal and structure

The geomorphic hazards imply different instability levels of the land, areas with morphometric and drain characteristics which cannot ensure the civil construction's durability and functionality on a long-term, but also imply geomorphic processes with frequent activations and reactivations and with considerable occurrence intensities in the construction's functioning and using interval.

In this regard, some basic principals must be taken into account (Fookes, Lee şi Griffiths, 2007) which define the manifestation pattern of geomorphic hazards in any territory, necessary for the implementation of civil projects in order to anticipate and prevent additional costs determined by the subsequent evolution of the geomorphic system where they are quartered and to avoid loses of human life:

- Local conditions are the product of geological and geomorphologic processes from the past
- Time distribution and the hazards' frequency can be explained by the system's response to the energy share fluctuations or by the progressive modification of the system's condition
- Hazard susceptibility's indicators and future change ratios can be determined taking into account how the systems respond to the environmental factors' modifications.

The general goal of this thesis is represented by the stated hypothesis' verification, the proposal of some *efficient models* for risk assessment and establishing some *concrete measures* for hazard management, *adapted to the conditions specific* to Baia Mare Municipality's complex geographical system.

Specific objectives:

1. Identification and mapping of dominating geomorphic processes that support the depression area and resulted landforms' dynamic;
2. Identification of the evolution direction of the valley-flank geomorphologic system in interdependence with the athropic component;
3. Identification and mapping of areas susceptible to the processes with hazard nature, using the processes and existing forms inventory;
4. Creating a predictive model of spatial probability for producing geomorphologic processes with hazard nature after testing some diverse models and methods;
5. Estimating some magnitude and frequency categories of geomorphic processes with hazard nature from the studied urban area;
6. Identification of the anthropic and anthropogenic structures' categories as hazard elements from the depression area;
7. Assessing the population and identified structures' vulnerability levels in the manifestation urban area of geomorphic hazards;
8. Creating the geomorphic harzard's map for Baia Mare Depression with detailed categories depending on the used variables for risk calculation;
9. Proposing some intervention measures (legislative, administrative, engineering etc.) for reducing the risk, by improving the prevention and refutal measures of the existing effects, taking into account the studied geographical system's evolutional tendency.

1.2. Methodological aspects and legislation

1.2.1 **Concepts' definition** of ***risk, vulnerability, disaster*** based on national and international literature.

1.2.2. **Hazards' classification**

1. Natural Hazards based on the *natural phenomenon's type* which underlies its **atmospheric (meteorological), climatic, hydrological, geological, geomorphologic, biologic/ecological** genesis. These were classified in two big categories:

a) *Geophysical hazards (meteorological, climatic, geomorphologic, geological and hydrological);*
b) *Biological hazards (climatic, geological and those related to the flanks' instability).*

2. Anthropic hazards occurred due to some *human actions* (induced fires, terrorist attacks, violent street manifestations, wars, sabotage etc.), of *technological origin* (in transportations, accidents with dangerous material, industrial explosions, fires, bridges collapse, nuclear accidents, the return and launch of spaceships from/in space etc.).

Other classifications, according to:

– ***hazards origin determined by:***

- extreme natural phenomena (meteorological, hydrological, geophysical, geomorphologic, of alien origin)
- normal natural causes (meteorological, geophysical, other types)
- biological agents (lues, pest invasion).

- Based on origin, hazards can also be classified as **endogenous** and **exogenous.**
- Depending on the ***environment where they occur:*** atmospheric, marine, continental.

- Another classification is that of Miletti (1999) who classifies the natural hazards in **climatic** and **geophysical.**

The hazard phenomenon being very complex is very hard to classify it as belonging to a sole origin; usually they occur due to multiple causes' disturbance.

1.2.3. **Used methods** adapted to the specific objectives and corresponding work phases.

- *bibliographical sources' analysis and synthesis.*
- *study area localization.*
- *making of the* working *cartographic frame* through specific GIS *digital mapping* techniques in order to roll-off the *spatial analysis* processes.
- *Identification and evaluation and mapping of areas with geomorphic processes* by *collecting* existing *data*, *surveying* the population, *consulting* topographical, geological, land using and orthophotographic *maps*, *direct observations on the field*, *GPS measurements*, *measuring* the resulted landforms' *dimensions* and the evolution speed in order to obtain the main geomorphic processes' map from Baia Mare Municipality.
- *Establishing the main geomorphic processes occurrence susceptibility (spatial probability) with hazard nature,* applying different *spatial analysis* methods through the instrumentality of

GIS techniques *(statistical method, heuristic method, methods that combine statistical models with heuristic assessment).*

- *Estimating the occurrence frequency and intensity of geomorphic processes with hazard nature,* using *the correlation* between its triggering and a causal factor, *the frequency analysis using* professional software (eg. Hyfran), *the observations and measurements;*
- *Making of the geomorphic hazards' map* by using *the cartographic method* with the help of GIS ArcMap 9.3 software, to classify the study area into hazard standard categories;
- *Estimating the vulnerability,* establishing risk exposure by *mapping* the main goods, people and activities (Sorocovschi, 2007), indicators' selection and quantification which describe these elements' vulnerability to a geomorphic risk, *the cartographic representation* of vulnerability;
- *Estimating the geomorphic risk* which implies *the synthesis* of geomorphic processes' occurrence potential (the hazard) and of damages to which risk elements are exposed (vulnerability) through the combination of previously obtained maps *GIS techniques* (Map Algebra), damages' *quantification;*
- *Identification of a series of intervention directions for reducing the risk,* focused on certain "critical points" from the studied area, *mapping* the relations and centres ("critical points").

1.2.4. Legislation. The paper was based on the national legislation, European directives which advert to the paper's subject. In the Protocol from the Accession Treaty of Romania to the European Union, Annex VII – Section Environment (31st of March 2005, Brussels), strict obligations are included, with precise deadlines for completion, which fall to our country concerning air, water, waste and industrial, agricultural, domestic pollution's quality, and risk management.

1.3. Context and justification

Throughout time, the city developed especially on Săsar's grazing land and ledges (representing 60% from the urban area's surface), areas which gave excellent lands for construction. In the last years, due to the rapid development of real estate buildings, the city expanded on the glacier (surface of almost 40% from the total urban area). In what concerns constructability, this area, raises special problems induced by natural hazards. If, at these, we add the geomorphic processes' implicit variety and dynamic, given the lithologic, hydrogeological and geological diversity, under an obvious modifications' tendency of some climatic elements, results a special complexity for finding optimal solutions for the stable and sustainable development of the whole urban area.

CHAPTER 2

LANDSCAPE

2.1. Geographical features

2.1.1 Geomorphologic recitals

The geographical coordinates (location, surface, limits, altitudinal energy gap, the main characteristics of the administrative-territorial unit's terrain (ATU) Baia Mare).

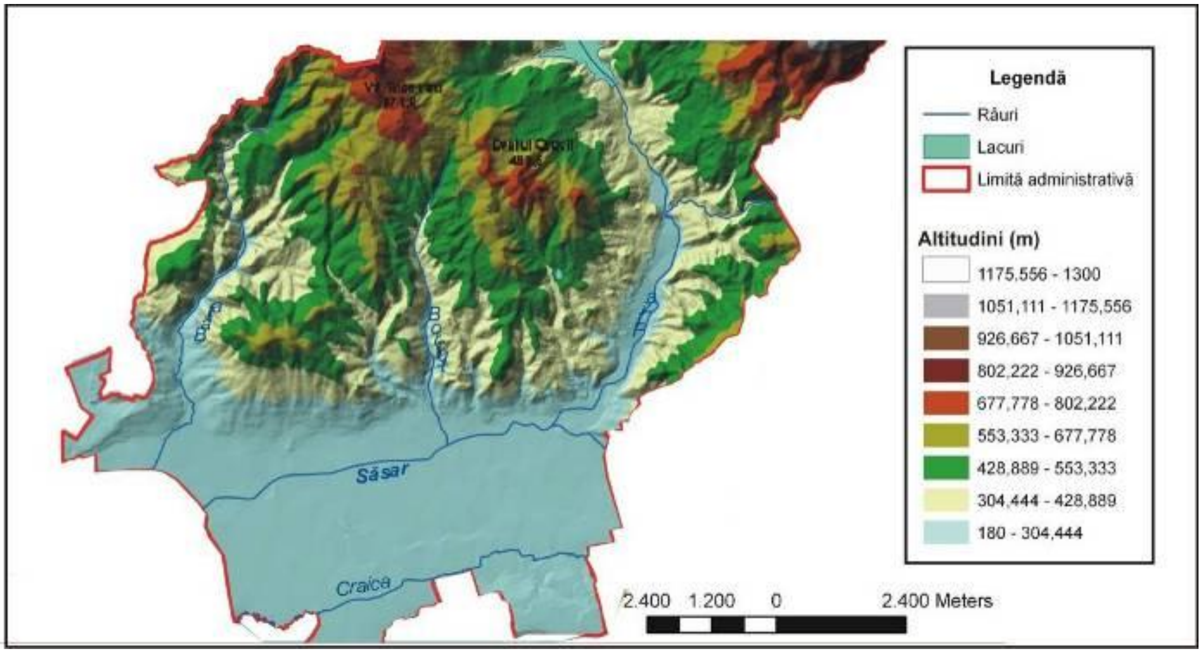


Figure 2.1 The hypsometric map of Baia Mare ATU

- The piedmonts and glaciers' slip (**Săsar Piedmont, Baia Mare Glacier** and its most important sectors which are *the most risk susceptible to landslides area, the Plain* with altitudes higher than 200 m fragmented by the main rivers Săsar, Lăpuş and Craica and by their feeders and *the superior and middle ledges Plain having under 200 m* which includes the large grazing lands of the main rivers - Săsar, Lăpuş and Craica – often subject to floods and the inferior ledges of 5-7 m and 18-25 m). Generally, the more developed ledges, according to the number and expansion on the left side of Săsar, give its valley an asymmetrical aspect due to its dislocation towards north by Lăpuş's course.

2.1.2 Morphometric elements

Slopes map for Baia Mare urban area. The largest part of the urban area has slopes between 0-1^o, corresponding to Săsar valley's couloir (Figure 2.2.). Here, it is included the ledge of 4-5 m from the right and left side of the river, the ledge of 20-25 m up to the Cărbuneasa Valley; towards the Lăpuş grazing land, the ledge of 20-25 m shows a distinct top with the slope of 10-20^o; these surfaces show a high durability, but are easily floodable if no regulation or channels' maintenance is done. This is the case of Craica beck, bended, a little deep and for the most part not damned up; if in the superior and middle course the minor channel, although bended, has shores of 1-3 m with slopes up to 30-50^o, in the inferior course, towards the confluence with Lăpuş, is a little built-in, the shores' slope not exceeding 10-15^o.

The piedmont slip between Borcut and Usturoi Valley, which gradually narrows from west to east, is characterized by slopes of 15-25^o, the contact with the mountain area (slopes of 30-40^o) being harsh. The mountain area, where slopes of 30-40^o prevail, is distinguished through the numerous presence of short but strongly deep valleys (flanks with slopes of 50-70^o), therefore, through in-depth erosion processes.

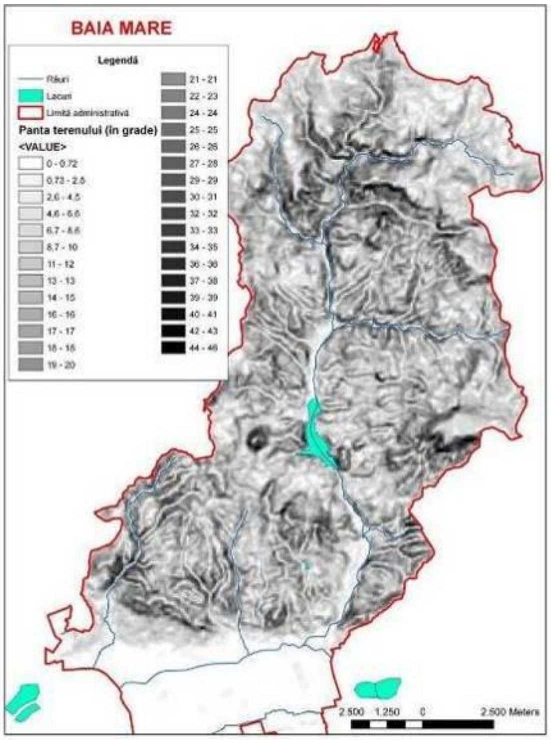


Figure 2.2 Slopes' map for Baia Mare ATU

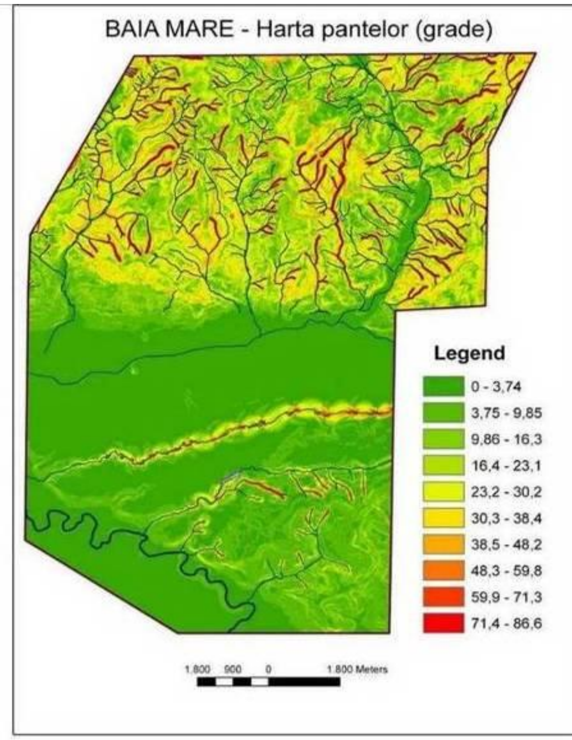


Figure 2.3 Slopes' map (in grades)

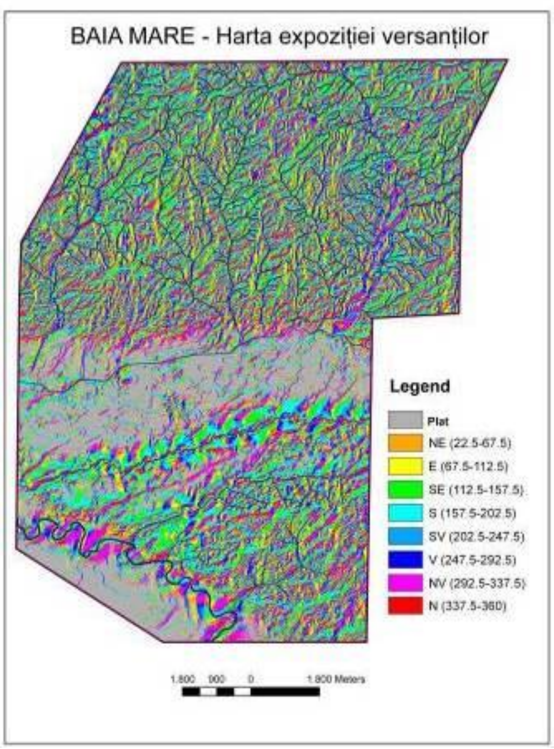


Figure 2.4 Flanks display map

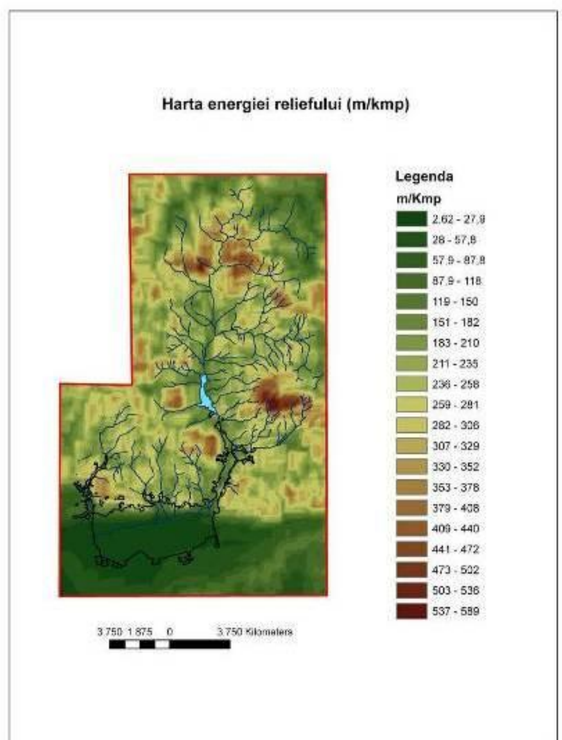


Figure 2.5 Terrain energy map

Flanks display. The elaborated map to this end for the urban area has the aspect of a mosaic for the mountainous area due to the terrain's pronounced fragmentation and to the fact that a pixel corresponds to a surface of 100 m^2 (Figure 2.4.). Although Săsar's grazing land and the ledge of 4-5 m are quasi-horizontal, thus, without a certain direction, their lessened and discontinuous surfaces with southerner, south-eastern and south-west orientation, favourable to the different urbanistic purposes, are remarkable.

Terrains energy map, constitutes in the same time one of the necessary factors/components for estimating *the susceptibility coefficient at landslide.* In the urban area, the smallest values (2, 62-27, 9 m/km^2) are found in the Săsar grazing land and on the 4-5 m ledge from its left side, where even the altitudinal differences on the surface unit are lower. On the similar ledge from the right side of the river, the terrain energy increases gradually up to values of 260-280 m/km^2 near to the Usturoi Valley and between Sf. Ioan and Vicleanul Mare Valleys. Punctually, in some isolated locations of the urban area on the left side of Borcut Valley, values of 450-470 m/km^2 are observable. The highest terrain energy's values, of 500-600 m/km^2 from Baia Mare ATU are found in the highest mountainous area, from Firizei origin and around Igniş crest.

2.1.3 Main climatic elements' characterization

The pluviometric and thermal, the cloudiness and eolian regime, the snowpack's characteristics etc. are analyzed in multiannual average and seasonal regime, using both the climatic studies' results made for Baia Mare urban area (PUG, Baia Mare, 2011; Filip, 2008; Coman, 2006; Dragotă, 2006), as well as those resulted from my own processing made based on meteorological data from the National Meteorological Administration.

2.1.2 Terranean and subterranean waters

2.1.4.1 Hydrographical network. Fathomizing in the same manner the area's morphohydrographical characteristic, the average altitude, the average and highest discharge, the average/basin rainfall, fluvial average discharge, the evapotranspiration's value etc. are analyzed. *The Săsar hydrographical basin*, the most important river from Baia Mare municipality's territory, *Firiza hydrographical basin* in the city's urban area sector, *the Strâmtori-Firiza accumulation lake* indicate the construction work phases, the hydrotechnic facility component, as well as the significant role for defending Baia Mare city against floods, *Săsar's small feeders,* as well as *Craica hydrographical basin,* direct feeder of Lăpuş.

2.1.4.2 The subterraneous waters monitored in 10 locations from which: 8 of I degree network soil logs and 2 of II degree network soil logs. Their qualitative state, the registered overflows in regard to the permissible concentrations provided in the effective norms: Arieşul de Câmpie F3, Arieşul de Câmpie F4, Arieşul de Câmpie F6, Baia Mare F6, Salsig F3, Coas F1, Satulung F1, Dumbrăviţa F1/II and Fărcaşa Sârbi F1/II.

2.1.5 Biopedogeographic characterization

The natural vegetation is distributed according to the climatic zonality and terrain's morphometric characteristics. The studied area is located within the vegetal associations, with the sub stage of beech and beech mixed with timber forests, especially specific to the high bordering units, the sub stage of hold forests and oak mixed with other deciduous forests (Coman, 2006). It is noted that *beech* develops in favourable conditions starting from 450 m, on shaded flanks, up to over 1250 m on the mountains' sunny flanks, filling significant surfaces at the level of high hills from Baia Mare (Filip, 2008), *the sub stage of oak and mixture of beech woods with holm forests* (Filip, 2008; Coman, 2006). On the piedmont hills' sunny flanks and on high ledges plain, at altitudes between 250-400 m, *hill causeways or oak forests mixtures* develop. In the low ledges and grazing land area, the sylvan vegetation is insular, represented through oaks, oak-holms with hornbeam, field maple, ash (Geografia României vol.1, 1983)

From a **pedological** perspective, Baia Mare urban area's space is characterized by: Eutric ambosoils, present starting from the altitude of 150-200 m, on parental materials made from marls, grit stones, andesites, on slowly or moderately declivitous flanks, with good draining off and Luvisoils which are formed on clays, sands, conglomerates, grit stones, some magmatic rocks, on poorly drained lands. An association with the holm or beech or grass land forests vegetation develops (Coman, 2006).

2.2 Geological and geotechnical features

Baia Mare Depression. It is a morpho-geological unit whose neogene molasse's filling situates it at the Pannonian Depression (especially its northern part from Baia Mare ATU). The basement is preponderant made of pannonian sedimentary deposits, interchange of marls and greyish clays, subordinated with the grit stones, bushes, small bushes and volcanic epiclastics (on the northern side of Baia Mare depression). At the quartz-andesites' superior side, a quartz-feldspathic grit stones compound with rare politic rocks' parting and cineritic and epiclastic frequency levels, appears. Inside the glacier area, isolate appearances of eruptive rocks are noticed in many sectors (pyroxene whinstones in the left flank of Borcut Valley, downstream from the mineral headwater, hyaline pyroxene andesites, quartz-whinstone andesites-andesites with pyroxenes and Băiţă hornblend, pyroxene andesites +/- Cruce-Hosodor Hill's hornblend, andesites with pyroxenes and Corb Valley's hyaline hornblend, or pyroclastics of these types of eruptive rocks, which represents durable sectors in larger morphodynamic instability areas).

Hydrogeological recitals. *The subterranean waters* are split into two big categories: down waters and upward waters. *The down waters* from the first water-bearing horizon with permanent resources and overphreatic waters, temporary accumulated in the aeration area located over the phreatic level. *The phreatic waters* are found in the Săsar ledges and Baia Mare glacier. The prevailing phreatic waters' feeding from Baia Mare glacier area is predominantly pluvial, what makes the seasonal pluvial fluctuations become an important factor. The phreatic waters from Baia Mare glacier area determine dealkanization truculence over the concretes from their action space. *The upward waters.* These are waters located in depth penetrable horizons, shielded by impervious horizons.

Geotechnical features. Baia Mare depression lends itself to a distinct zonation which includes: ***the lower area*** (Săsar river's inferior ledges) with excellent lands for setting; ***central area*** (middle and superior ledges that also cover the Groşi Crest) with good lands for setting and ***the high area*** (a slip that surrounds the depression, made of glaciers, piedmonts and hills with areas affected by landslides).

PART TWO: IDENTIFICATION AND ANALYSIS OF GEOMORPHIC, CLIMATIC AND HYDROLOGICAL HAZARDS

In the second part, the **geomorphic hazards'** analysis and identification are discussed with special attention to the actually affected areas by landslides and the creation of a susceptibility map for landslides, to the **climatic hazards** with the special atmospheric phenomena analysis and the creation of climatic hazard maps and **hydrological hazards** which included the analysis of the hydrographical network, the morphometric elements, the hydrological regime as well as to extreme hydrological phenomena (floods), finally carrying through the municipality's flooding map. Also, hydrological disturbances phenomena induced by mining activities, as well as those given by waste water over the hydrographical network and the phreatic waters, were analyzed.

CHAPTER 3

IDENTIFICATION AND ANALYSIS OF GEOMORPHIC HAZARDS FOCUSING ON LANDSLIDES

3.1 Geomorphic hazards classification (after I.A.Irimus, 2006): mass dislocation processes: landslides, caving-ins, landfalls, rock slides, adobe discharges, solifluxion, creep, settlement; fluvial-denudation lineal erosive processes: trickles, cloughs, pouring.

3.2 Conceptual and methodological aspects concerning the identification and analysis of landslides

When choosing and developing evaluation methods for susceptibility, hazard and landslides' risk, a strong correlation must exist between methodology and the scale where the studies are performed. The method's mismatch with the work scale can give if not wrong, then incomplete results. The representativeness level accounted or proven to be optimal and the performed operations' efficiency impose the embracement, depending on the scale to which is worked on, of certain methods, qualitative or quantitative, used solely or complementary.

3.2.1 ***Conceptual phases:***

Landslides inventory based on some methodologies developed in studies at regional and national level in countries such as France, Poland, Great Britain, Italy, Spain, Canada, SUA and Romania (Surdeanu, Mac, Grecu, Popescu, Chendeş, Bălteanu etc.).

The susceptibility evaluation at landslides, the identification of areas that can be inclined to landslides in the future, is made through ***qualitative and quantitative approaches*** by *bi-variable* or *multivariable* statistical methods (probabilistic and deterministic). When choosing variables depending on which landslides are analyzed, we must take into account a series of their properties (Ayalew, Yamaghishi, 2005): to be *operational,* to be *complete* (allotted on the entire studied area), *irregular* (to vary in space), *measurable, not to be redundant* (not to have double consequences for the final result). The essential phase is the final one, of map validation through field verifications or through probabilistic calculus methods, such as *fuzzy logic, Bayesian probability,* even if it involves the *probability* concept it also gives a susceptibility map, without taking into consideration landslides' frequency in time, but only their occurrence probability in space. Also within the quantitative approach the *deterministic method* is included, where the morphography and morphometry elements (slope, display, flanks' profile) are filled in by identification elements of hydrologic and hydrogeological nature in order to carry on, for example, flank durability coefficient's analyses with the help of some GIS program or add-ons such as SINMAP, SHALSTAB, CHASM etc.

Hazard's evaluation at landslides. Hazard's evaluation methodology can be split into three main groups: models of *"white box"* type (deterministic methods based on physical models), *"black box"* models (strictly based on the statistical analysis) and *"grey box"* models (partially based on statistic and determinism). Either based on evaluations (dislocation speed, emission and regressive evolution's distance) and on mappings, either based on the graphic representations' study (aerial-survey photograph, big resolution satellite images) that can represent landslides' distribution on a certain time interval. Based on this information, the temporal probability can lap over the spatial one (represented by the susceptibility map) allowing for *the hazard* to be represented. The end goal of these hazard studies is to obtain a risk evaluation as accurately as possible to which different people or communities confronts with. Therefore, to get to this final destination, the people or communities' vulnerability to such geomorphologic processes must be taken into consideration. Recent studies define the risk as being:

$$R = H \times C \times E,$$

where R = risk; H = hazard; C = consequences; E = elements at risk

formula that can be synthesized as:

$$Risk = \Sigma\ (H\ \Sigma\ (VC)\ ),$$

- hazard (H) being the spatial and temporal probability function of an event's occurrence with destructive potential, and the elements at risk's vulnerability (V) is expressed from 0 to 1 depending on these elements' cost values (C) (whether we are talking about people, whether we are talking about their goods, whatever their nature is).

Therefore, risk studies aim to evaluate the threat level that a certain process displays as accurately as possible in order to establish some measures, this process being entitled as *risk estimation.* A quantitative analysis has as final goal the risk's quantification, its articulation in values (from 0 to 1, from 0 to 100% monetary units etc.) for a more suggestive exemplification of it (Bell, Glade, 2004).

In all cases, *the vulnerability's quantification* has the biggest importance. In literature, two different ways of looking at vulnerability are distinguished: from the social sciences perspective and from natural sciences perspective.

In the engineering and natural sciences fields, vulnerability represents a part of the analysis – the perception – the evaluation – the risk management, being extremely important for determining the consequences, representing the loses' degree of a certain element (or sets of elements) at risk, which results from an event's occurrence of a certain magnitude, being represented on a scale from 0 (without loses) to 1 (total loses), expressed in monetary value (in case of material loses) or in victims (in case of human life loses).

Hazard map's elaboration at landslides. So far are known: *Territorial areas map with potential landslides* (Tufescu V., 1966), *Romania's land zoning from the landslides' occurrence potential perspective* (Marchidanu E., 1995), *Lands with landslides' map* (UTCB, 1997), *Soils* *durability map in Romania* (PROED S.A., 1966), *Landslides' induced risk macro-zonation map in Romania* (GEOTEC S.A., 1998).

For the landslides' occurrence probability the morphometric particularities of the lands' terrain (slope, terrain energy), their lithologic composition (first of all the clays' presence), seismic framing, climatic and hydrological particularities, and the way of using the lands are taken into account.

3.2.2 Used methods for landslides' study. GIS techniques method which has many main phases:

- Carrying out my own field research and measurements, data acquisition from local and national authorities etc.;
- Obtaining information, the information sources for SIG covers diverse forms, such as the existing maps at different scales, on material body or digital (topographic, geologic, soil, vegetation etc.), numeric data, aerial-survey photographs, satellite images etc.;
- Computing information digitally and the database creation;
- Choosing the data model (vector or bitmap) used for analysis and the available digital information's conversion in that model, data processing and interpretation in order to obtain the intermediary map;
- Obtaining the final maps and some reports.

The continuous surface can be represented through a **bitmap data model** (also named *grid*). A square cell grille "covers" the land. A bitmap cannot represent at a certain point just one variable, and this variable's values are defined for each cell. A point from the vector model can be estimated in the bitmap data model through a singular cell.

The spatial intercalation represents a set of methods based on which the properties' values from some points where there is no information based on known values from other points, where there is information, from the same study surface, it can be estimated. These can be: *local or global pole; estimated or exact pole; gradual or acclivitous pole; deterministic or stochastic pole.* Another land's susceptibility at landslides calculus methodology was developed by the Geography Institute's team and published in the international professional magazine *Geomorphology* (Balteanu Chendeş, 2010). This refers to the entire territory of Romania, and was adapted in this paper to Baia Mare city's urban area. To obtain the susceptibility map at landslides, a susceptibility indicator was calculated taking into account six factors: lithology, slope, terrain energy and land using, precipitation and seismicity.

Statistical method. For establishing landslides's occurrence susceptibility, one of the most used methods is the multivariable statistic. Logit type lineal probability models (logistic regression) represent one of these multivariable analysis' techniques and uses more variables to determine one dependent variable, not measurable (Hair et al., 1992). To accomplish this, we start by mapping the causal factors or parameters both in the landslides' area, as well as in the spaces without landslides along time (Crozier and Glade, 2005). A positive coefficient increases the susceptibility, and a negative one decreases it (hair et al., 1992). For establishing the variables which will be introduced in the statistical calculus, it is used the Akaike Information Criterion (AIC value) created by Hirotsugu Akaike in 1971, as a matching degree measure of an estimative statistical model. The lower the value of this indicator is, the better the model is. For the area adjoint to Baia Mare municipality's urban area, the logistical regression was performed using as variables (landslides' preparatory factors) the slope, terrain energy and lithology; with this combination of factors, AIC value indicating the best statistical model. The highest susceptibility coefficient's value was of 0,86, and the resulted map was reclassified using the included categories in the Government Decision 447/2003, as following: 0-0,05 – without susceptibility; 0,05-0,1 – lessened susceptibility; 0,1-0,3 – average susceptibility; 0,3-0,5 – average-high susceptibility; 0,5-0,8 – high susceptibility and 0,8-0,86 – extremely high susceptibility.

Construction's durability insurance method GT-019-98. Risk coefficient K_m's value and geographical distribution estimation and establishing the landslide potential P, on the territory of Baia Mare municipality's urban area. The regulatory documents upon which the involved causes' evaluation in the lands' equilibrium state are: Government Decision no. 382/2003 and Government Decision no. 447/2003.

The methodology used in the project. Landslides' susceptibility map elaboration, understanding by this this phenomenon's occurrence spatial probability and expressed through a scale from 0 to 1 (K_m coefficient) or based on a percentage from 1 to 100 as probability (P), was performed using GIS techniques in conformity with Law 572/2001, Law 124/1995, Government Decision 382 and 447/2003 and Ministry of Public Works and Territorial Arrangement Order 62/N/1995/1998, based on the *Writing guide for risk maps at flanks landslides to ensure construction durability – Indicative GT-019-98* . The phases necessary for map's elaboration were the following:

- *Field researches (landslides' mapping and measurements).*
- *GT-019-98 Indicator's Analysis* and documentation with the necessary and in conformity with this informative materials. The indicator is synthesized in the following formula:

$$K(m)=\sqrt{\frac{K(a)\times K(b)}{6}\times[K(c)+K(d)+K(e)+K(f)+K(g)+K(h)]}$$

where: $K_{(a)}$ = lithologic criterion;
$K_{(b)}$ = geomorphological criterion;
$K_{(c)}$ = structural criterion;
$K_{(d)}$ = hydrological and climatic criterion;
$K_{(e)}$ = hydrogeological criterion;
$K_{(f)}$ = seismic criterion;
$K_{(g)}$ = sylvan criterion;
$K_{(h)}$ = anthropogenous criterion.

- *Performing the land's digital model.*
- *Determining the slopes (in degrees).*
- *Thematic maps elaboration adequate to each criterion.*
- *Transforming the thematic maps in bitmaps (grids).*
- *Giving points for each criterion and reclassifying the adequate bitmaps.*
- *Calculation of the K_m susceptibility coefficient* using the *Spatial Analyst* module and the *Map Calculator* function associated with ArcView 3.1 and ArcGis 9.0 programs.
- *Model validation* – confronting the areas with landslides risks, as they appear on the resulted map, with the land's reality. (Figure 3.1., 3.2., and 3.3.)

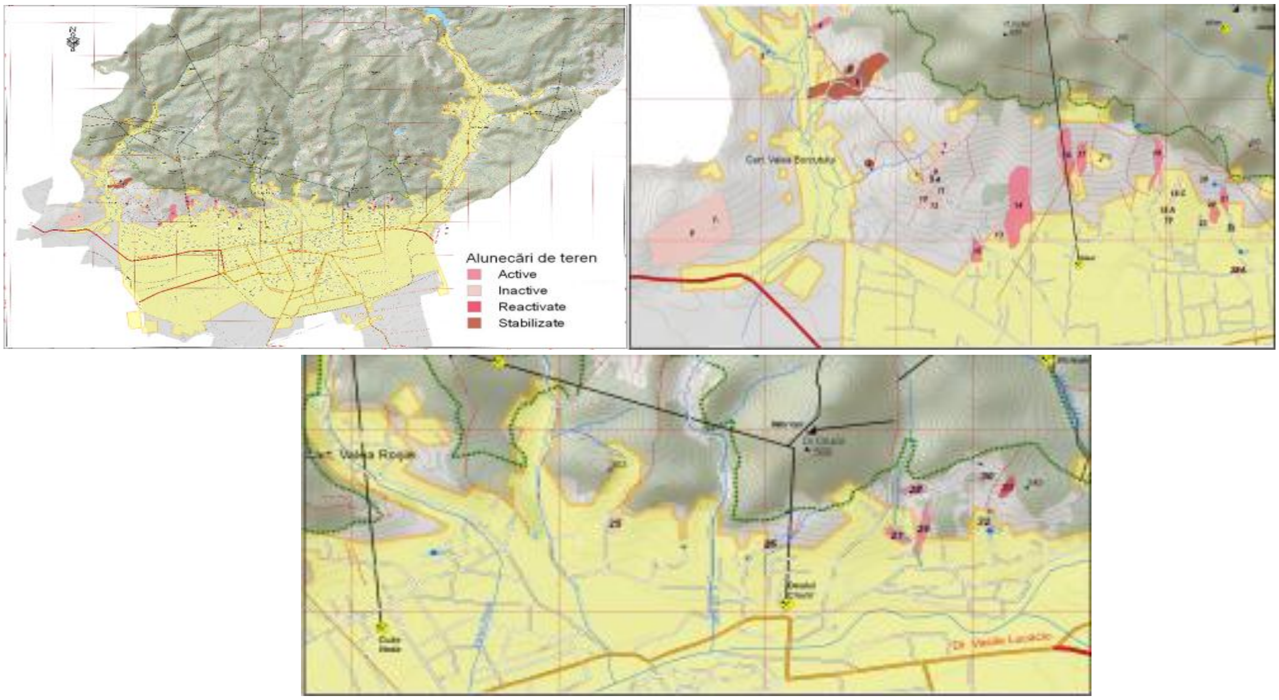


Figure 3.1, 3.2, 3.3 Flanks' landslide risk maps for insuring construction's durability – GT-019-98 Indicator

Three degrees of the landslides' occurrence potential were established (low, average and high) (table 1) depending on the K_m coefficient's value according to table no. 3.1.:

Table 3.1: Landslides' occurrence potential and risk potential

Landslides' occurrence potential					
Low		Average		High	
Landslides' occurrence probability (P%) and the adequate risk potential (K_m)					
Zero	Low	Average	Average-High	High	Extremely High
0	< 10	10 – 30	31 – 50	51 – 80	> 80

We mention that the recorded assessments on the elaborated maps in the 1:25000 scale concerning the landslides' occurrence probability show a generalization degree imposed by the information precision and dating over the factors taken into account in conformity with the *Writing guide for risk maps at flanks landslides to ensure construction durability – Indicative GT-019-98.* K_m coefficient's risk values were calculated according to the table found below (table 3.2.):

Table 3.2: K_m – P correlations and the surfaces

	K_m	P	Surface. (ha)
I. Dura Area			
Landslide 7	**0.50**	average-high	3,34
Landslide 8	**0.23**	average	7,95
II. Borcut Valley district area			
Landslide 2	**0.23**	average	0,38
Landslide 3	**0.19**	average	0,22
Landslide 4	**0.47**	average-high	0,87

Landslide 5-6	**0.35**	average-high	8,07
III. Miron Costin Street area			
Landslide 1	**0.12**	average	1,43
Landslide 9	**0.16**	average	1,57
Landslide 10	**0.19**	average	0,98
Landslide 11-12	**0.19**	average	1,64
Landslide 13	**0.51**	**high**	0,57
Landslide 14	**0.52**	**high**	7,88
Landslide 15	**0.24**	average	1,25
IV. Nuc Street area			
Landslide 16	**0.52**	**high**	2,93
landslide 17	**0.52**	**high**	1,37
V. Săsar district area			
Landslide 18	**0.39**	average-high	1,20
Landslide 19	**0.53**	**high**	1,63
Landslide 20	**0.23**	average	0,58
Landslide 21	**0.26**	average	0,77
Landslide 22	**0.50**	average-high	0,24
Landslide 22A	**0.39**	average-high	0.00
Landslide 23	**0.34**	average	0,79
Landslide 24	**0.21**	average	0,10
VI. Usturoi Valley area			
Landslide 25	**0.19**	average	0,50
VII. Griviţa district area			
Landslide 26	**0.38**	average-high	0,19
Landslide 27	**0.42**	average-high	0,58
Landslide 28	**0.41**	average-high	0,61
Landslide 29	**0.28**	average	0,96
Landslide 30	**0.20**	average	0,09
Landslide 31	**0.26**	average	0,51
Landslide 32	**0.18**	average	0,16
VIII. Ferneziu area			
Landslide 33	**0.52**	**high**	0,11
IX. Cărămizi Street area			
Landslide 34	**0.53**	**high**	0,04
Landslide 35	**0.22**	average	0,25

3.3 Susceptibility at landslides

Land's susceptibility at landslides' map both for Baia Mare ATU as well as for the urban area, was based on the two methodologies, that from the Government Decision 447/2003 concerning the *Methodological elaboration norms and to the content of natural risk maps for landslides and floods* materialized in the *Writing guide for risk maps at flanks landslides to ensure construction durability – Indicative GT-019-98* and another one, derived from the first and improved, tested and used in the Romanian Academy's Geography Institute. Both take into account the most significant natural and anthropic indicators which compete at triggering the landslides. At Baia Mare ATU's level, the average and low categories in the mountain area prevail. The following sectors can be differentiated:

Roşie – Usturoi Valleysector. Although it has steep slopes, has a low morphodynamic potential due to the sedimentary deposits being made of stable andesitic rocks.

Florilor Hill sector has a medium morphodynamic potential, the expansion of sedimentary rocks from the substratum being relatively low.

Crucii Hill sector constitutes an area with low morphodynamic potential, restrained by the presence on the surface of rigid andesitic pyroclastics.

Amadei – Firizei Valley sector. With a large development of coluvio-proluvial deposits, and towards the east side, and of eruptive rocks fixed till the glacier and the steep slope's base.

The Firizei Valley upstream sector reveals an alternate development of the pannonien and quaternary deposits. The piedmont deposits were removed through erosion from the land between the Săsar river and the volcanic formations, and at the base of the erosion glacier formed on the sedimentary formations, a coluvio-proluvial accumulative glacier was formed.

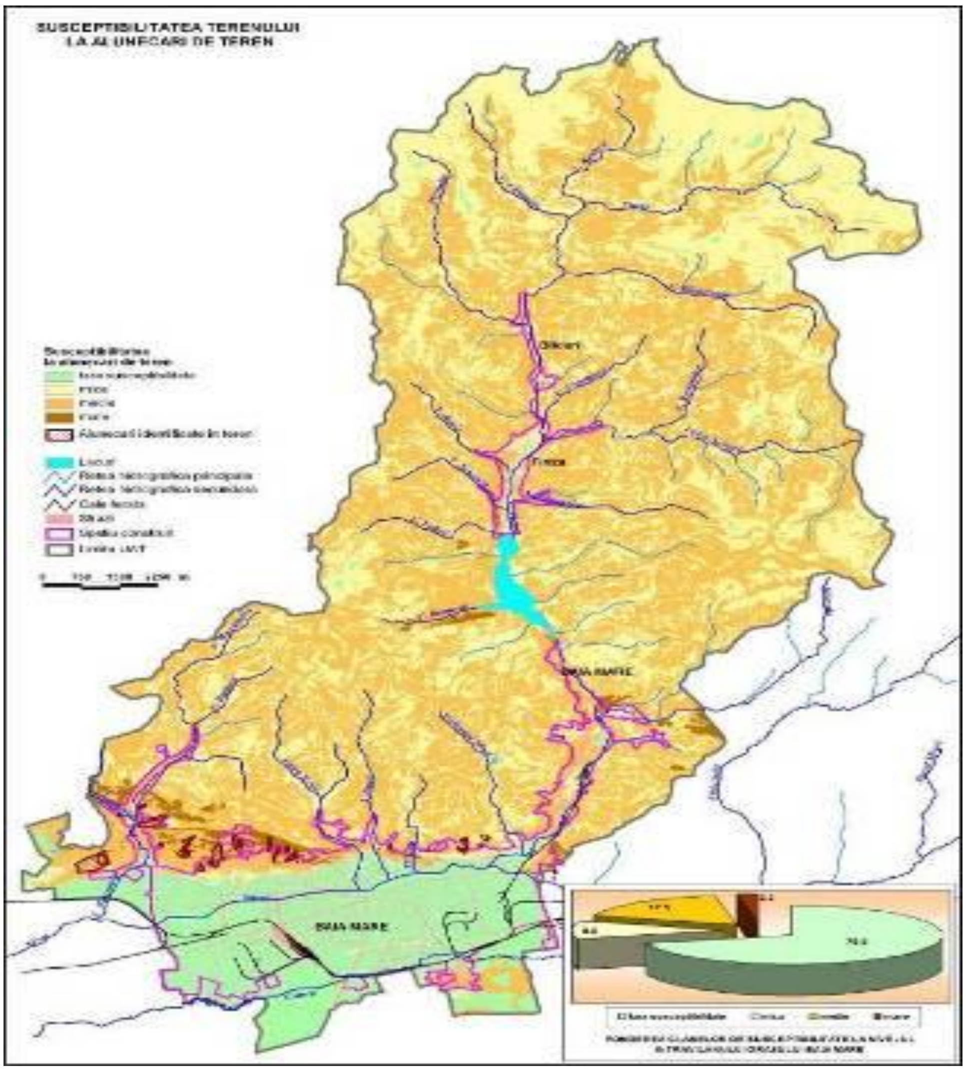
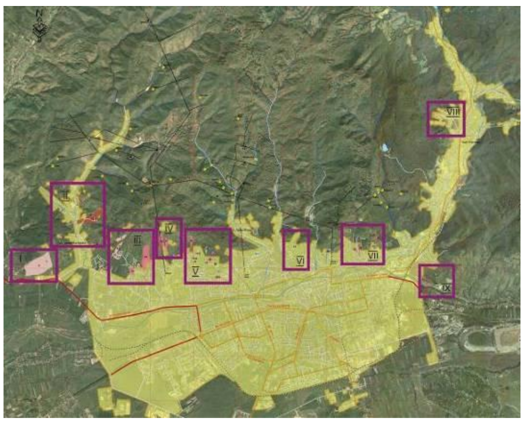


Figure 3.4 Land's susceptibility at landslides map

The urban area's susceptibility at landslides' map underlines the fact that 71% of its surface is durable, not jeopardized by landslides; nevertheless, just inside it, small areas with low and average susceptibility values of appear and 2,2% of the urban area has a high susceptibility at landslides.

3.4 Identification of areas with landslides

To perform this project the GIS ArcInfo software was used. The instruments and applications included in this product, offer the possibility to create, maintain and establish the topography between the spatial objects and spatial objects categories. The GPS Correct from Trimble was used in order to correct the data from the field. Trimble Planning uses for correction the Almanac files with *SSF and *COR extension (it is downloadable from the Trimble website in the day after the field trip). The correction stations which are closer to our location are set up (ideally being less than 200 km), respectively Baia Mare station (Figure 3.5)



I. Dura Area
II. Borcutul Valley district area
III. Miron Costin Street area
IV. Nuc Street area
V. Săsar distict area
VI. Usturoi Valley area
VII. Griviţa district area
VIII. Ferneziu area
X. Cărămizi Street area

Figure 3.5 The map with the identified and mapped areas (after Baia Mare PUG)

I. DURA AREA (the southern flank of Dura Hill) (Figure 3.6.) represents a hilly piedmont made of neogene, clayey sedimentary rocks. In the area's southern part, two sub-areas affected by landslides were identified: the cemetery and the fruits garden.

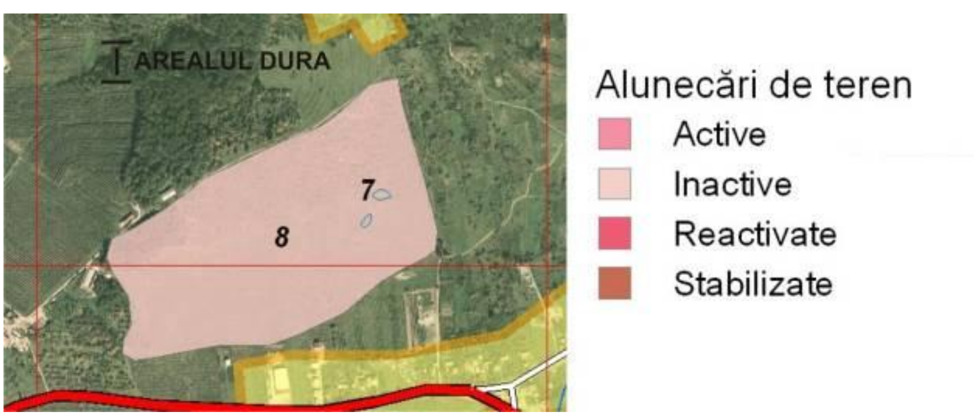


Figure 3.6 Map with Dura area

Table 3.3

OBJECTIVE	CRITERION								Risk Coefficient
	lithologic	geo-morpho	structural	hydro-climatic	hydro geologic	seismic	sylvan	anthropogene	
	Ka	Kb	Kc	Kd	Ke	kf	Kg	Kh	
I. Dura Area									
Landslide 7	0.7	0.8	0.8	0.8	0.6	0.1	0.2	0.2	**0.50**
Landslide 8	0.4	0.4	0.6	0.8	0.3	0.1	0.2	0.0	**0.23**

Landslide 7 THE CEMETERY. It is located near Victoria Street junction with Independenţa Boulevard, close to the parallel street with Baia Mare-Satu Mare E58 national road. *Measurements:* Surface 3, 34 ha, average length 230 m, average width 1, 65 m.

Conclusions: **Low depth landslide** (1-5 m), **active**, due to water accumulation from previous landslides' crippling, having a risk coefficient $\mathbf{K_m}$**=0, 50** and occurrence potential from **average to high** (table 3.3.).

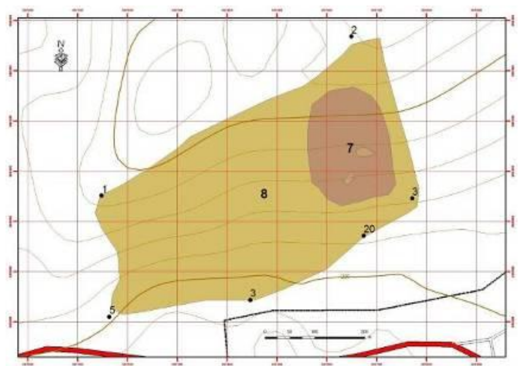


Figure 3.7 Dura's area topographic map

II. BORCUT VALLEY AREA (Figure 3.7). From all the landslides from this area, the following are significant: **Landslide 2** (Figure 3.8) located in the left flank was affected by low landslides in May 1970, having as main cause the long time abundant rains, occurred in this period. When field researchers were made, the phereatic water from the fountains was situated around the level of -1,80 m.

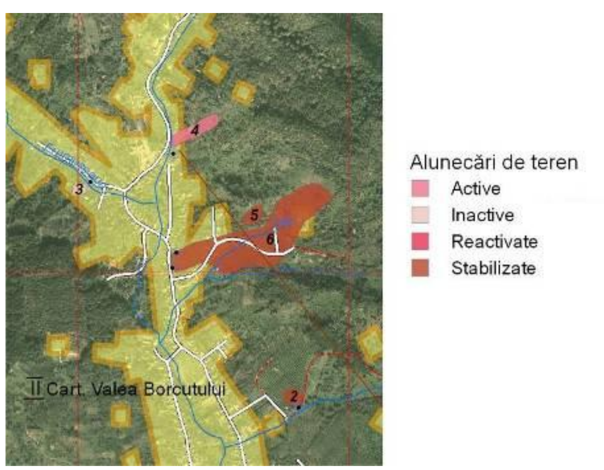


Figure 3.8 Borcut Valley's area map

Table 3.4

OBJECTIVE	CRITERION								Risk Coefficient
	lithologic	geo-morpho	structural	hydro-climatic	hydro geological	seismic	sylvan	anthropogene	
	Ka	**Kb**	**Kc**	**Kd**	**Ke**	**kf**	**Kg**	**Kh**	
II. Borcut Valley district area									
Landslide 2	0.4	0.4	0.6	0.8	0.2	0.1	0.2	0.1	**0.23**
Landslide 3	0.3	0.4	0.5	0.8	0.2	0.1	0.1	0.1	**0.19**
Landslide 4	0.7	0.7	0.8	0.8	0.6	0.1	0.3	0.1	**0.47**
Landslide 5-6	0.5	0.6	0.7	0.8	0.6	0.1	0.2	0.1	**0.35**

III. MIRON COSTIN Street AREA. Miron Costin Street is a street that covers crosswise the slope at the foot of Iricău hill. The street was made since the hill was a fruits garden of Baia Mare International Accounting Standards for the machines' access. After land retrocession, it became an attractive residential area. Along this street many sectors with landslides were identified, inactive, active or reactive (Figure 3.9):

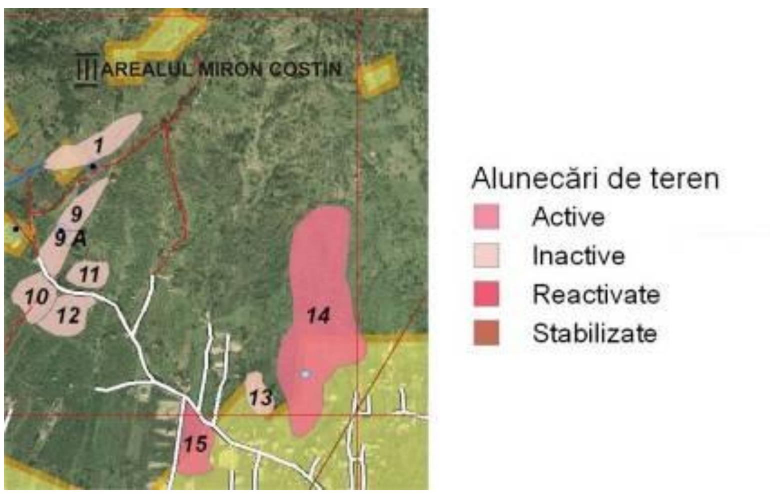


Figure 3.9 Map with Miron Costin area

Table 3.5

OBJECTIVE	CRITERION								Risk Coefficient
	lithological	geo-morpho	structural	hydro-climatic	hydro geological	seismic	sylvan	antropogene	
	Ka	**Kb**	**Kc**	**Kd**	**Ke**	**kf**	**Kg**	**Kh**	
III. Miron Costin Street Area									
Landslide 1	0.2	0.3	0.0	0.6	0.3	0.1	0.2	0.3	**0.12**
Landslide 9	0.3	0.3	0.5	0.7	0.2	0.1	0.2	0.1	**0.16**
Landslide 10	0.3	0.4	0.5	0.7	0.2	0.1	0.2	0.1	**0.19**
Landslide 11-12	0.3	0.4	0.5	0.7	0.2	0.1	0.2	0.1	**0.19**
Landslide 13	0.7	0.8	0.7	0.8	0.7	0.1	0.3	0.2	**0.51**
Landslide 14	0.8	0.7	0.5	0.8	0.8	0.1	0.4	0.3	**0.52**
Landslide 15	0.4	0.4	0.6	0.8	0.4	0.1	0.2	0.0	**0.24**

Landslide 11-12. The landslide that crosses Miron Costin Street, at east from the previous one (Figure 3.10).

Right now, it is a stabilized landslide, at least downstream from the street (obviously due to the existing sewage). Some land unevenness, destroyed house gratings are noticed, even on the leg that separated the large small valley's area from the landslide from sector 1. Landslides from this sector, due to land dislocations, are noticed also upstream from Miron Costin Street. *Conclusions.* The **stabilized** landslide has a risk coefficient of **K_m=0, 19** and an **average** occurrence potential. The area does not have buildings, and the land's slope is of almost 20^o upstream from the street and 20-30^o downstream.

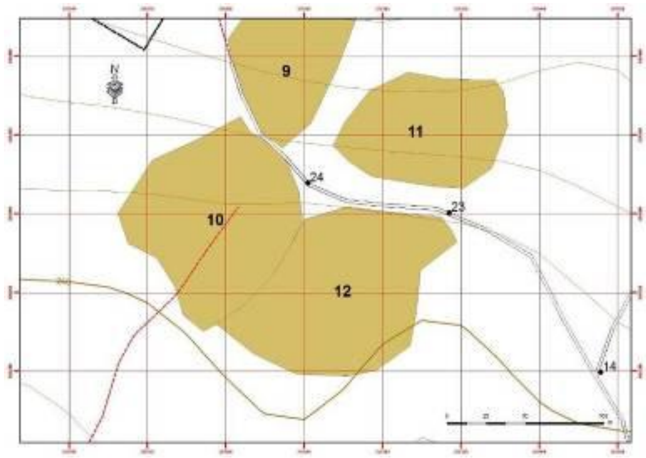


Figure 3.10 Topo map landslide 11, 12

Figure 3.11 Landslide 11

Figure 3.12 Landslide 12

IV. NUC Street AREA

In the built space, the urbanistic works do not allow anymore the identification of possible landslides, although these existed along a valley which branches upstream. From the last house, the road advances between two gullies (Figure 3.13). On the east, one landslide appears in the area right in front of the existing cemetery occurred before the year 1960. The land is waved, irregular, with bended trees, with surface puddles, on a width of almost 120 m. The slope from the landslide area is of 12-15^o.

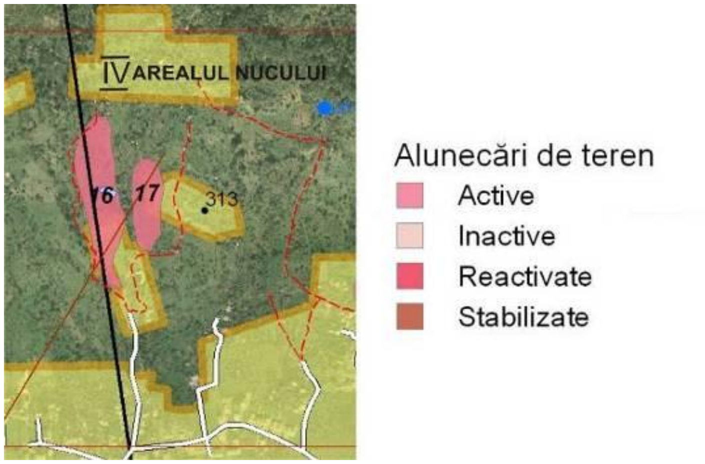


Figure 3.13 Map with Nuc area

Table 3.6

OBJECTIVE	CRITERION								Risk Coefficient
	lithologic	geo-morpho	structural	hydro-climatic	hydro geological	seismic	sylvan	antropogene	
	Ka	Kb	Kc	Kd	Ke	kf	Kg	Kh	
IV. Nuc Street Area									
Landslide 16	0.7	0.8	0.8	0.8	0.6	0.1	0.3	0.3	**0.52**
Landslide 17	0.7	0.8	0.8	0.8	0.7	0.1	0.3	0.2	**0.52**

Landslide 16. West landslide (Figure 3.14 and 3.15). The west small valley shows landslides just above the last houses. The land is slipped, grassy, with a fruits garden, but quite a lot of bended bearer trees are noticed. The landslides area is located under the grit stone benchmark level and represents the inferior side of the large landslide above the grit stone level. Around the grit stone steep's area, the sedimentary material has a thickness of over 4 m, made of quart-andesites fragments caught in a sandy soil, a little more ferruginous at the base (in the waters' accumulation area).

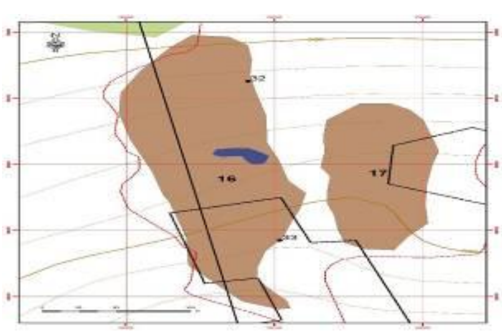


Figure3.14 Topo map landslide 16

Figure 3.15 -Landslide 16

Upstream from the cemetery, on the small valley from the left side, the landslide area extends up to the forest's margin. It is an area with excess surface water and ponds. In 1974, here there were houses that were destroyed by landslides. The golden-agers' grandparents said that landslides affected this area also in the years 1923-1924. *Measurements:* Surface 2, 93 ha, longest length 400 m, average width 75 m. *Geological data.* The landslide occurs at the contact between clays and pannonien marls, over the arenaceous benchmark level. *Conclusions.* The landslide from upstream from the cemetery is an **active** landslide, of low depth (affects only the quaternary adobe deposits), having a risk coefficient of **K_m=0, 52** and a **high** occurrence potential.

V. SĂSAR district AREA (Figure 3.57)

Landslide 24 – Fructe Street east (Figure 3.16) located in the previous landslide's complex towards east. In the flute from the street's northern end, a big water contribution that enters into the sewage network is noticed. The land from upstream from the houses on the northern side is occupied with fruits garden and has a morphology characteristic to some areas with landslides: ledges separated by more bended steeps which represent old landslide's dislocations, areas with morphological irregularities.

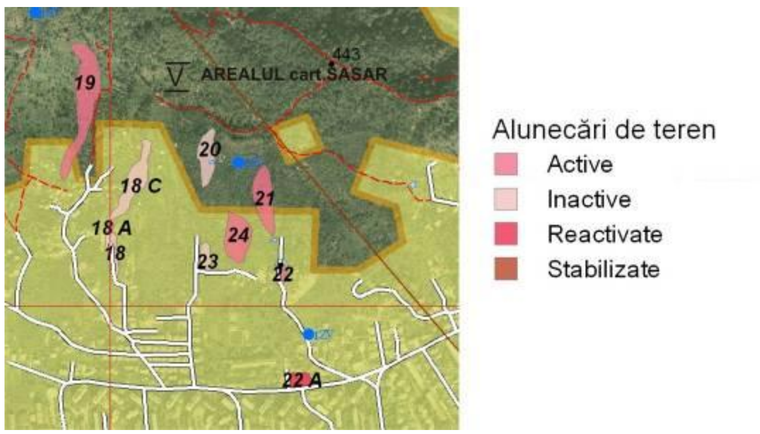


Figure 3.16 Map with Săsar district area

Table 3.7

OBJECTIVE	CRITERION								Risk Coefficient
	lithologic	geo-morpho	structural	hydro-climatic	hydro geological	seismic	sylvan	anthropogen	
	Ka	**Kb**	**Kc**	**Kd**	**Ke**	**kf**	**Kg**	**Kh**	
V. Săsar district area									
Landslide 18	0.6	0.6	0.6	0.8	0.6	0.1	0.3	0.2	**0.39**
Landslide 19	0.7	0.8	0.8	0.8	0.7	0.1	0.3	0.3	**0.53**
Landslide 20	0.4	0.4	0.6	0.8	0.2	0.1	0.2	0.1	**0.23**
Landslide 21	0.4	0.5	0.5	0.8	0.3	0.1	0.2	0.1	**0.26**
Landslide 22	0.7	0.7	0.8	0.8	0.8	0.1	0.3	0.3	**0.50**
Landslide 22A	0.6	0.6	0.7	0.8	0.5	0.1	0.2	0.2	**0.39**
Landslide 23	0.4	0.6	0.7	0.8	0.7	0.1	0.3	0.3	**0.34**
Landslide 24	0.4	0.4	0.4	0.8	0.2	0.1	0.2	0.0	**0.21**

Measurements: Surface 0, 79 ha, longest length 128 m, average width 65 m.
Geological data: The landslide is located at the pannonien grit stones benchmark level's base.

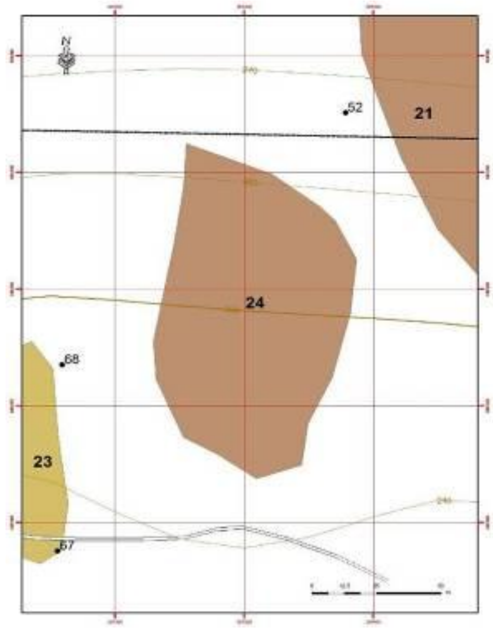


Figure 3.17 Topo map landslide 24

Figure 3.18 Landslide 24

Conclusions: The old landslide, **inactive**, of low depth, occurred due to an ooze water excess, accumulated at the contact of pannonien clay-loamy formations having a risk coefficient of $\mathbf{K_m=0,21}$ and an **average** occurrence potential.

VI. USTUROI VALLEY AREA

Until 40-50 years ago, in the area from the south of Flori Hill there were many more active and stabilized landslides. The building of ethnography and folk art Museum led to the stabilization of a vast area by creating a paved flute on contour line, in order to impound waters. Land irregularities due to landslides were also present until 5-8 years ago upstream from the Flori Hill baithouse, in the currently flattened, drained and built area (Figure 3.19).

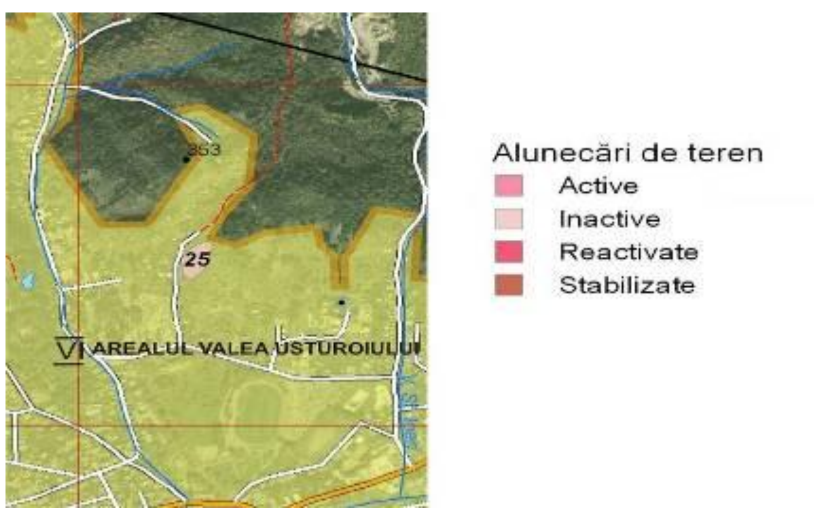


Figure 3.19 Usturoi Valley area map

Table 3.8

OBJECTIVE	CRITERION								Risk Coefficient
	lithologic	geo-morpho	structural	hydro-climatic	hydro geological	seismic	sylvan	anthropogen	
	Ka	Kb	Kc	Kd	Ke	kf	Kg	Kh	
VI. Usturoi Valley area									
Landslide 25	0.3	0.4	0.4	0.8	0.2	0.1	0.2	0.1	**0.19**

Landslide 25 – Flori Hill Street. (Figure 3.20, 3.21 and 3.22) is located in the street's eastern part, upstream from the reformed cemetery. Some older trees have the base bended upstream and the superior part vertical, which shows the existence of some old landslides, now stabilized. The land is out of level, with furrows and rents also upstream up to the pyroxene andesites' inferior limit, and towards east, up to the ethnography and folk art Museum's fence. According to the trees' thickness, the landslide seems to be activated in the period 1970-1980.

Geological data: In the landslide's area there are no rock fragments of the substratum, but in upstream, in the performed diggings for replacing the reformed cemetery's fence, pannonien grey clays fragments appear, the quaternary deposits thickness being lessened (almost 1,5 m). Besides, on Flori Hill Street, before pavement, there were daily abruptions in the pannonian sedimentary condo (clays, marls, small bushes). *Conclusions:* The landslide is **stabilized**, old, of low depth (affects only the covering quaternary deposits having a risk coefficient of $\mathbf{K_m=0, 19}$) and an **average** occurrence potential (Table 3.8)

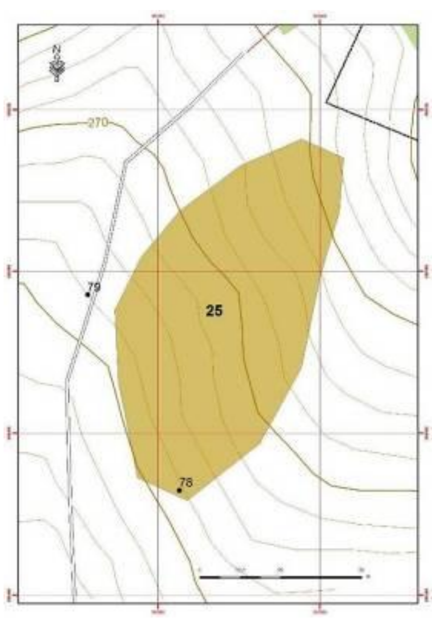


Figure 3.20 Topo map landslide 25

Figure 3.21 and 3.22 Landslide 25

VII. GRIVIȚA district AREA

The area south of Cruce Hills is relatively stable, due to sedimentary rocks' lessened development at surface. In the street's central part, in the performed diggings for some new houses' gratings, a quaternary deposits' lessened thickness is noticed (less than 1 m), the substratum being made of volcanic pyroclastics. The fountains have a depth of 6-7 m. In the rainy periods there also is ooze water, the water level in the fountains increasing to -2 m (Figure 3.23).

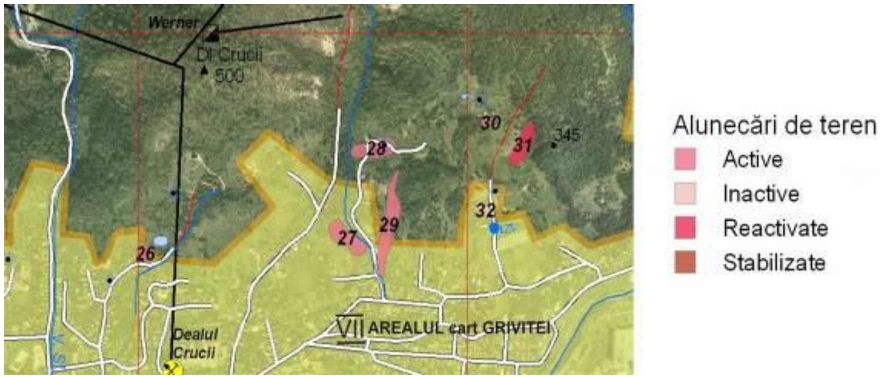


Figure 3.23 Griviţa district area map

Table 3.9

OBJECTIVE	CRITERION								Risk Coefficient
	lithologic	geo-morpho	structural	hydro-climatic	hydro geological	seismic	sylvan	anthropogen	
	Ka	Kb	Kc	Kd	Ke	kf	Kg	Kh	
VII. Griviţa district area									
Landslide 26	0.5	0.6	0.6	0.8	0.7	0.1	0.4	0.3	**0.38**
Landslide 27	0.6	0.6	0.8	0.8	0.8	0.1	0.2	0.3	**0.42**
landslide 28	0.6	0.6	0.7	0.8	0.7	0.1	0.3	0.2	**0.41**
Landslide 29	0.4	0.6	0.6	0.8	0.2	0.1	0.2	0.1	**0.28**
Landslide 30	0.4	0.4	0.4	0.7	0.1	0.1	0.1	0.1	**0.20**
Landslide 31	0.5	0.5	0.4	0.8	0.0	0.1	0.2	0.1	**0.26**
Landslide 32	0.3	0.4	0.4	0.8	0.1	0.1	0.2	0.1	**0.18**

Landslide 27 – from Amada Valley's right flank. (Figure 3.24 and 3.25). In the year 2008, the land's owner of the valley's right flank cleared the land and started its offset, fact which determined a landslide both in the digging's area, as well as upstream from it. The land dislocation was produced at the end of the summer and determined the dislocation towards east of the water's course from Amada Valley. The land's slope from Amada Valley's left flank is of 30-40^{o}. In the parcel above the landslide area, terrain's slope decreases to 10-15^{o}. *Measurements.* Surface 0, 58 ha, longest length 135 m, average width 45 m.

Geological data. The landslide also affects the pannonian substratum, marls and bushy grey clays' fragments (with rare clayed feldspars) were noticed at surface. *Hydrological data.* In the landslide's active area, a consistent contribution of subterraneous water is noticed.

Figure 3.24 Landslide 27

Figure 3.25 Landslide 27

Conclusions. **Active** landslide determined by anthropic digging works in a sector with a lot of subterraneous water having a risk coefficient of K_m**=0, 42** and occurrence potential from **average to high.**

VIII. FERENZIU AREA (Figure 3.105)

Tabel 3.10

OBJECTIVE	CRITERION								Risk Coefficient
	lithologic	geo-morpho	structural	hydro-climatic	hydro gelogical	seismic	sylvan	anthropogen	
	Ka	Kb	Kc	Kd	Ke	kf	Kg	Kh	
VIII. Ferneziu area									
Landslide 33	0.7	0.8	0.8	0.8	0.7	0.1	0.3	0.2	**0.52**

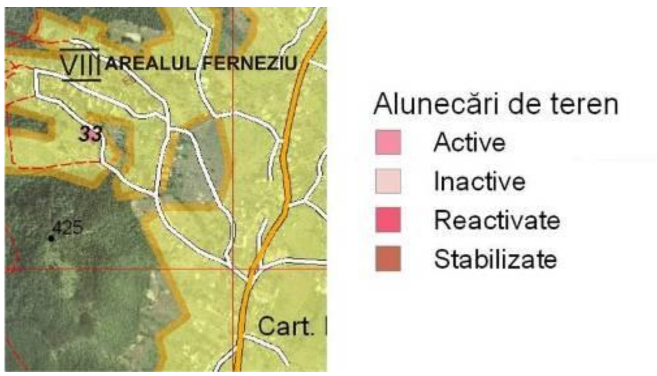


Figure3.26 Ferneziu area map

Landslide 33 – from Haiduci Street (Figure 3.26) is an extremly recent landscape (was produced in the evening of 8 December 2010) which affected a small area, located in a valley's steep left flank, given long and abundant precipitation.

Measurements. Surface 0, 11 ha, longest length 41 m, average width 27 m.

Geological data. The landslide affects adobe deposits made of andesitic fragments caught in a brownish matrix, formed from some clayed and limotizated andesites' decay. These adobe deposits' thickness is of at least 9 m (according to the data from a nearby fountain). The substratum is constituted from hydrothermally transformed andesites.

Hydrological data. In the thick adobe deposits from the area and in the quaternary deposits' base we can find phreatic water (at 9 m in a fountain from upstream). Besides this, subterranous oozes are found at the superior levels that have surface feeding.

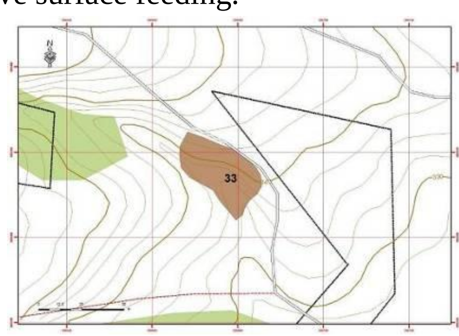


Figure3.27 Topo map landslide 33

Conclusions. The **active** landslide of small dimensions, average depth, due to abundant precipitation collected and managed through thick adobe deposits, on a route with a very small width having a risk coefficient **K_m=0,52** and a **high** occurrence potential (Table 3.10).

IX. CĂRĂMIZI Street AREA (Figure 3.109)

Figure 3.28 Cărămizi Street area map

Table 3.11

OBJECTIVE	CRITERION								Risk Coefficient
	lithologic	geo-morpho	structural	hydro-climatic	hydro geological	seismic	sylvan	anthropogen	
	Ka	**Kb**	**Kc**	**Kd**	**Ke**	**kf**	**Kg**	**Kh**	
IX. Cărămizi Street area									
Landslide 34	0.7	0.8	0.8	0.8	0.7	0.1	0.3	0.3	**0.53**
Landslide 35	0.4	0.4	0.4	0.8	0.2	0.1	0.2	0.1	**0.22**

Cărămizi Street is located at the limit between Baia Mare and Tăuţii de Sus, near the area with vast landslides from the previous clay pit of brick fabric.

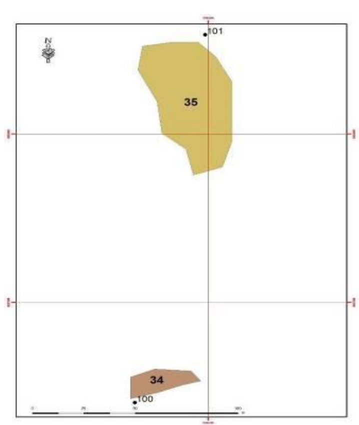


Figure3.29 Topo map landslide 34

Figure 3.30and 3.31-Landslide 34

CHAPTER 4

IDENTIFICATION AND ANALYSIS OF CLIMATIC HAZARDS

4.1. Climatic hazards classification

According to Florin Moldovan „Fenomene climatice de risc" (2003) the classification, after the time criterion is: of short time, of average time, of long time, of extremely long time. The climatic hazards that generally affect the north-west of Romania have regional characteristics according to the type of atmospheric circulation and to the geographical position related with the terrain's major landmarks, to which it is added the exterior climatic influences and the prevailing type of time, influenced by the Carpathian's orographic dam, through its position, altitude, massiness, direction and form. Generally, Baia Mare depression area is exposed, through its position and specific particularities, to the ***thermal, pluvial and mixed risks,*** determined by the main climatic factors: atmosphere's general circulation, solar radiation and the subjacent active surface (PUG Baia Mare 2011).

4.3. Identification of climatic hazards parameters. The establishment of meteorological elements' particularities: thermal regime, pluviometric regime, relative humidity, eolian regime, as well as special atmospheric phenomena.

4.5. Analysis of climatic hazards from Baia Mare municipality

Based on the complex classifications (Bryant, 1991; Croitoru and Moldovan, 2005) as well as my own studies developed at local lavel and adapted to the analyzed region's particularities, a main climatic risks' regionalization was carried out, taking into account the frequency, time and intensity parameters of the main thermal, pluvial and mixed phenomena. This set of extreme climatic phenomena ***according to the occurrence moment during the year*** underlines the moments of the year when certain climatic risks have the biggest impact over the environment leading to the identification of **specific climatic risks to the cold semester of the year, climatic risks from the warm season of the year** and **climatic risks with occurrence throughout the year** (Dragotă et al, 2009a; Dragotă et al, 2009b; Dragotă, Grigorescu, 2010).

The climatic risks from the cold season represent the negative thermal deviations from the normal state caused by: the baric centers' position towards the interest area, the cooling processes' frequency and intensity and the circulation speed of air-masses types. These genetic conditions are amplified/diminished by the subjacent surface's characteristics. The main climatic risks from the cold semester of the year especially felt in Baia Mare Municipality's area are:

Temperature inversions conditioned by terrain's configuration towards the circulation's direction of air-masses tributary to the prevailing baric centers during the year, as well as the massive cooling processes' frequency and intensity of the dry and frosty air. In Baia Mare municipality's area, the temperature inversions during winter, presents in the north part, *mixed and average vulnerability* which in the area's remaining parts is favoured by a wide opening towards Someş Plain (Figure 4.1).

These, associated with the average frost period on the soil's surface of 190-215 days/year in the depression cut-off and with the 215-240 days/year on the surrounding flanks with altitudes higher than 800 m, the average degrees, respectively mixed by vulnerability to the temperature inversions during the winter, are augmented.

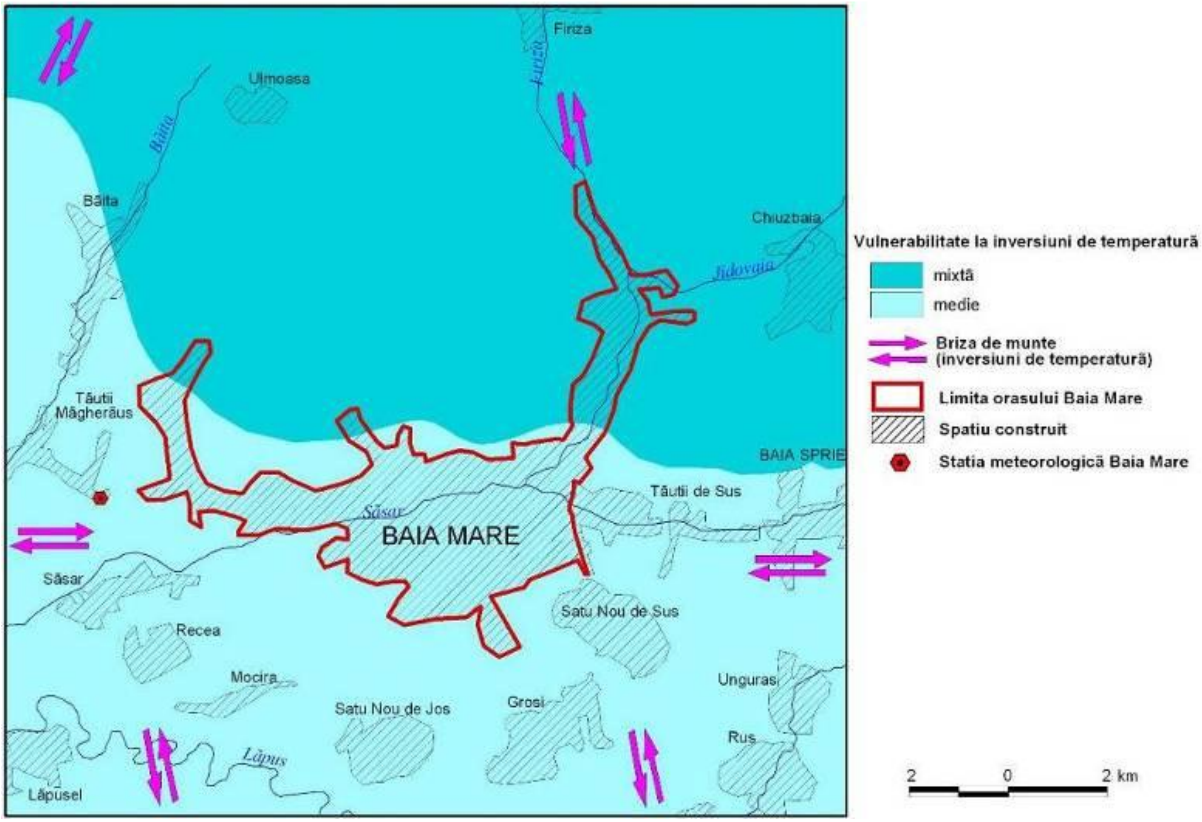


Figure 4.1 Vulnerability to temperature inversions in Baia Mare municipality's area

Polar or arctic cold waves and the negative thermal singularities appear more evidently when the absolute lowest temperatures are registered in temporal sequences with long (cold waves) or short (thermal singularities) durations and on larger/smaller surfaces.

The days with characteristic temperatures are also specific to the cold semester of the year: lowest temperatures $\leq 0^0$C (days with frost) and highest temperatures $\leq 0^0$C (winter days). In case of the former, the year's interval is longer (September-June), and on percentage these do not exceed 28.5 in a year, the winter days are observable only in the November-March interval and have an annual balance of 7.2. The thermal hazard represented through extreme temperatures in daily average values, does not have a significant variability energy gap, underlining the more clement climate given by the harbour conditions specific to Baia Mare depression (over which the most part of the municipality laps) flanked by the surrounding mountainous massifs' orography.

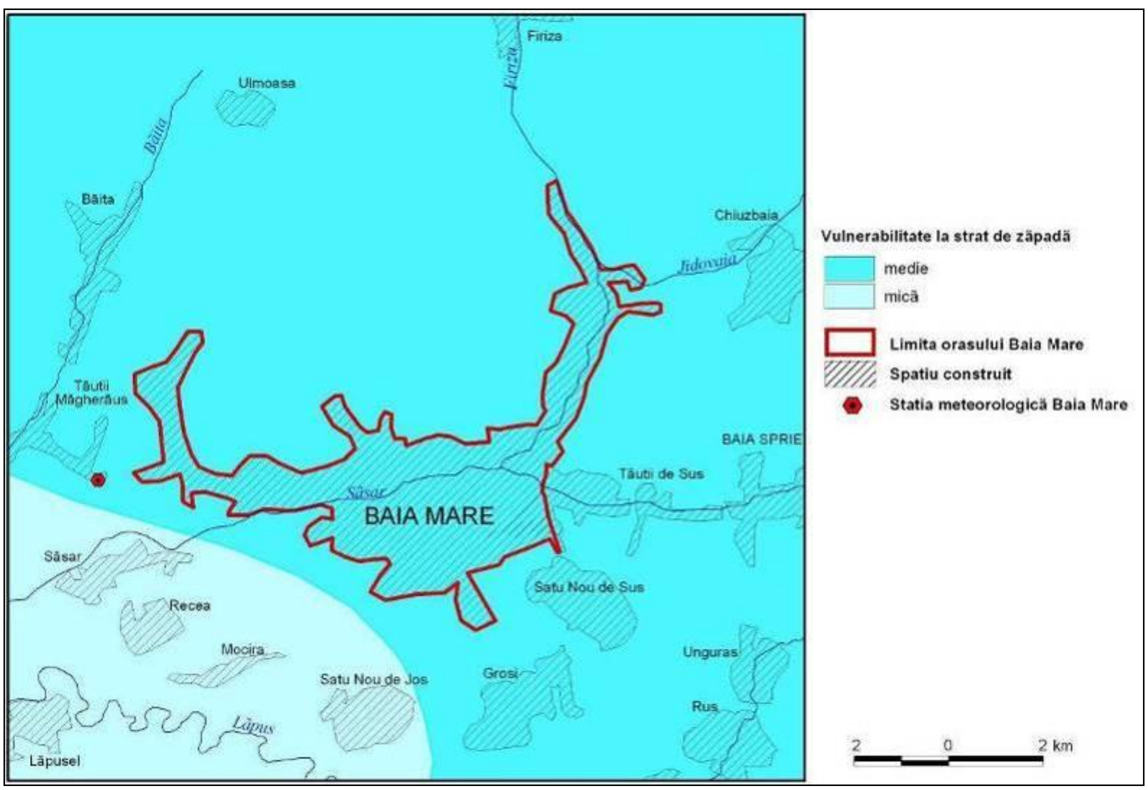
The heat waves during winter which trigger floods. The positive temperatures' existence, with values higher than the winter months' averages generated in time intervals higher than hourly, condition these climatic risks' existence during winter. The generated effects by these heat waves during winter, materialized through positive temperatures with a variability energy gap belonging rather to the year's warm semester, are externalized through sudden snow debacle in the same time with the appearance of abundant rains and floods' triggering. On the climatic risks' map, the heat waves during winter which trigger floods will be represented through the oceanic air masses' prevailing direction.

The snowpack is characterized through thickness, uniformity, structure and density, the last two being directly independent. In multiannual average, an interval's average duration with a durable snowpack between 100-150 days results. The studied area's vulnerability degree to this climatic hazard is *average* throughout Baia Mare municipality's entire area and *low* in the bordering area's western extremity.

The slush and humid snow occur at the cold season's beginning and end and are related to the temperatures' fluctuation around the O^{o}C threshold, by the presence and value of condensation centers' concentration in the free atmosphere and of relative humidity with increased values.

These hydrometeors form the climatic hazard character with more destructive effects than the snowpack. Generally, the studied area presents *an extremely high vulnerability* to these hydrometeors for the most part and *high* in the bordering area's south-west part (Figure 4.3).

Ice depositions on aerial wires result from the over-cooled off water's freezing (in the shape of fog, foggy air, drizzle, rain), through the sublimation process and through the snowflakes or slush's aeration and freezing. These deposition's characteristic parameters are: large and small diameters, weights, depositions' type, density and duration. In Baia Mare Municipality, this dangerous meteorological phenomenon's presence covers the September-October interval, until May and occurs for 21-30 days/year. The highest number of days during a year can reach 51-100, determining an *average vulnerability* (Bogdan, Marinică, 2007).



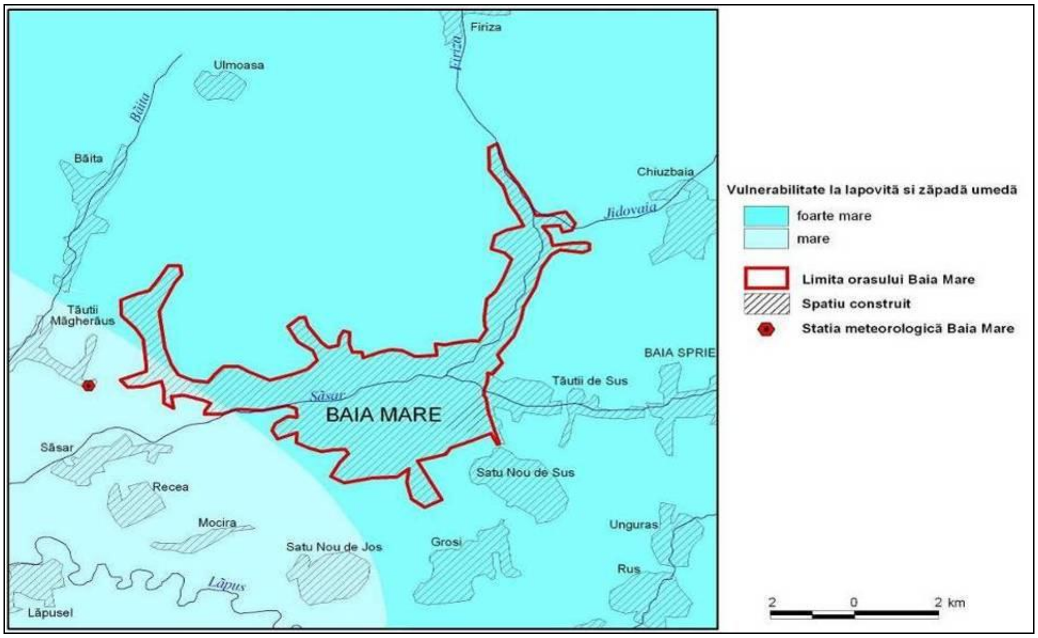


Figure 4.2 and 4.3 Vulnerability to snowpack as well as to humid snow in Baia Mare municipality

Climatic hazards from the year's warm semester are determined by the positive irregularities' significant exceeding in comparison with the multiannual average, being triggered by the atmosphere's general circulation in correlation with the solar radiation and the subjacent surface's nature and these include:

The heat values and the positive thermal singularities are generated by the warm, sometimes tropical air's advections. The positive temperatures' record registered in Baia Mare Depression is of 39.2^{0}C (22.VIII.1943) comparable with those registered in the same period in the south of Romania, but exceeded – in the second case – in the last years, which classifies the analyzed region as the *average vulnerability* area for this thermal hazard.

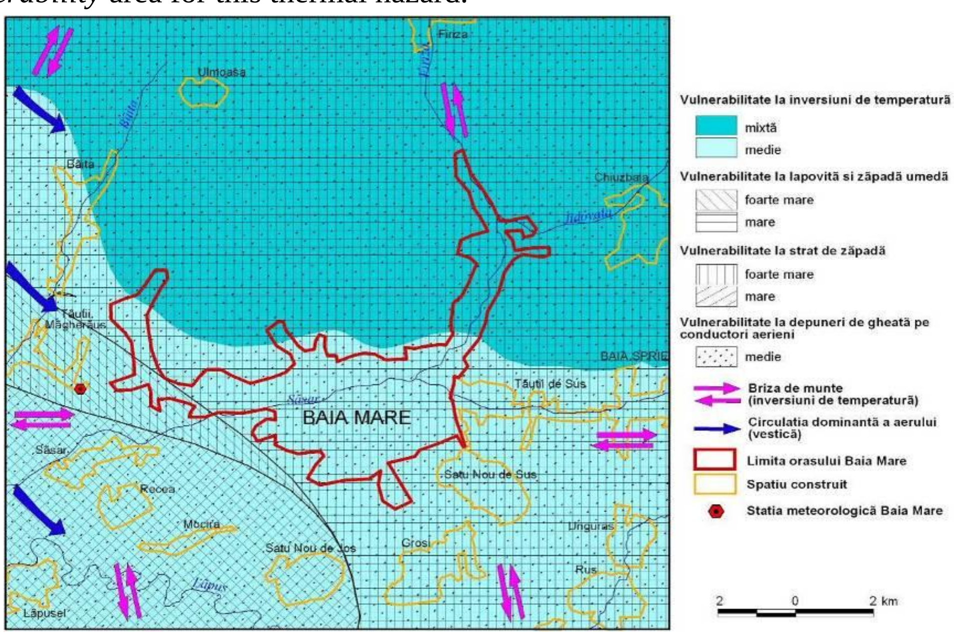


Figure 4.4 Climatic hazards from the year's cold season in Baia Mare municipality's area

Hail storms. The climatic hazard character is determined by the ice hailstones' size, the duration, the fallen water quantity, the downpour's intensity and the wind's speed which trigger the storm preceding the hail. Baia Mare municipality presents, for the most par, an *average* and *high vulnerability* to this meteorological phenomenon (Bogdan, Marinică, 2007).

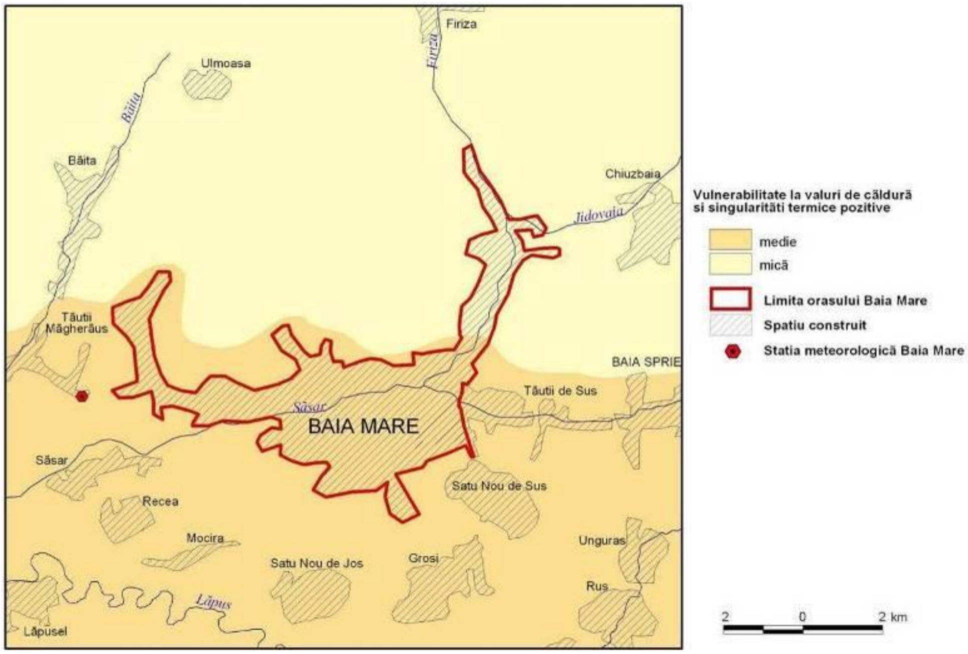


Figure 4.5 Vulnerability to heat values and positive thermal singularities in Baia Mare municipality

Climatic hazards with occurrence throughout the year. Through these dangerous meteorological phenomena's representativeness through parameters of intensity, duration and frequency, but also as impact over the environment:

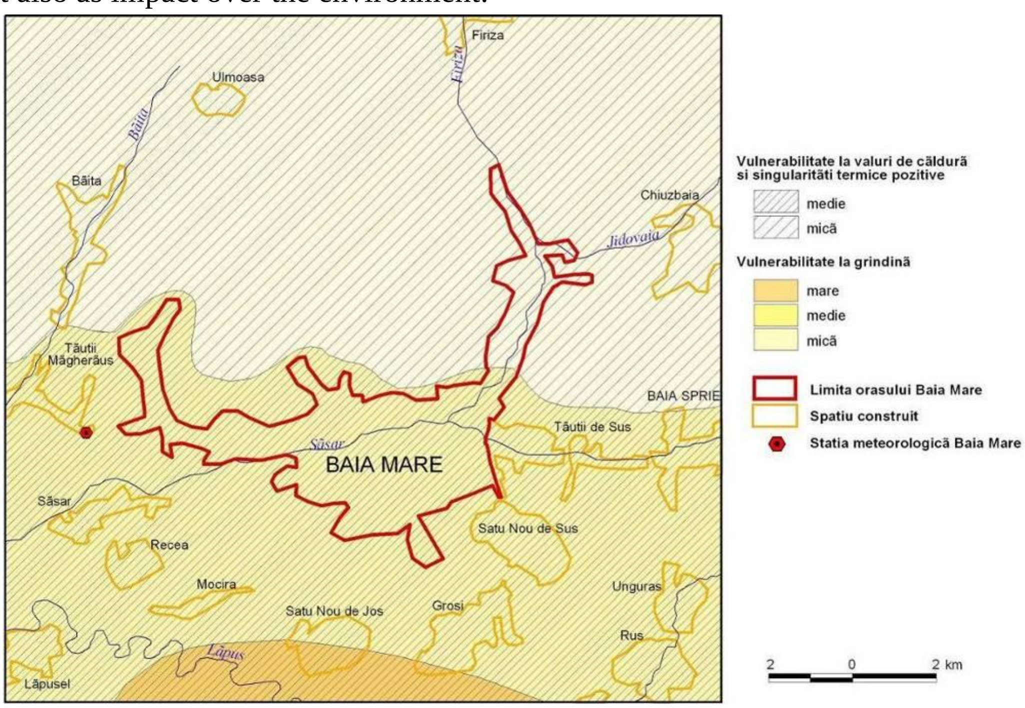


Figure 4.6 Climatic risks from the year's warm season in Baia Mare municipality's area

Pouring rains. In Baia Mare municipality's area, ***the pluviometric monthly extreme*** during the year is registered in the month of *June*, characteristic to the inter-Carpathian depression area. The multiannual monthly average (1961-2007) of the rainiest month of the year was encoded at 103.5 mm. In the studied climatic area, usually in the *months April-September from the most rainy years* 200 mm were exceeded in the years 1912, 1913, 1915, 1924, 1970, 1985, 1998, 2001, 2004-2006. In the months of November and sometimes January, which, for most times, lapped over some moderate towards high temperatures, trigger floods especially in the small hydrographical basins tributary to Săsar and Lăpuş. Such situations are characteristic to the years: 1985 (November and December), 1990 (November), 1993 and 1994 (December), 1995 (November and December), 1999, 2004, and 2007 (November and December).

The environment's vulnerability to this climatic hazard takes into consideration, especially, the pluvial intensity, which, in the analyzed area, reaches some of the highest values. Thus, the highest five decreasing values' average of the pluvial intensity from the period 1971-2000 was between 3-4 mm/min in Baia Mare, fitting to the areas with *high vulnerability* to pouring rains. When defining this vulnerability level, the basic criteria were the rains' average intensity between 0.03-0.04 mm/min and the average highest intensity of 0.20-0.30 mm/min.

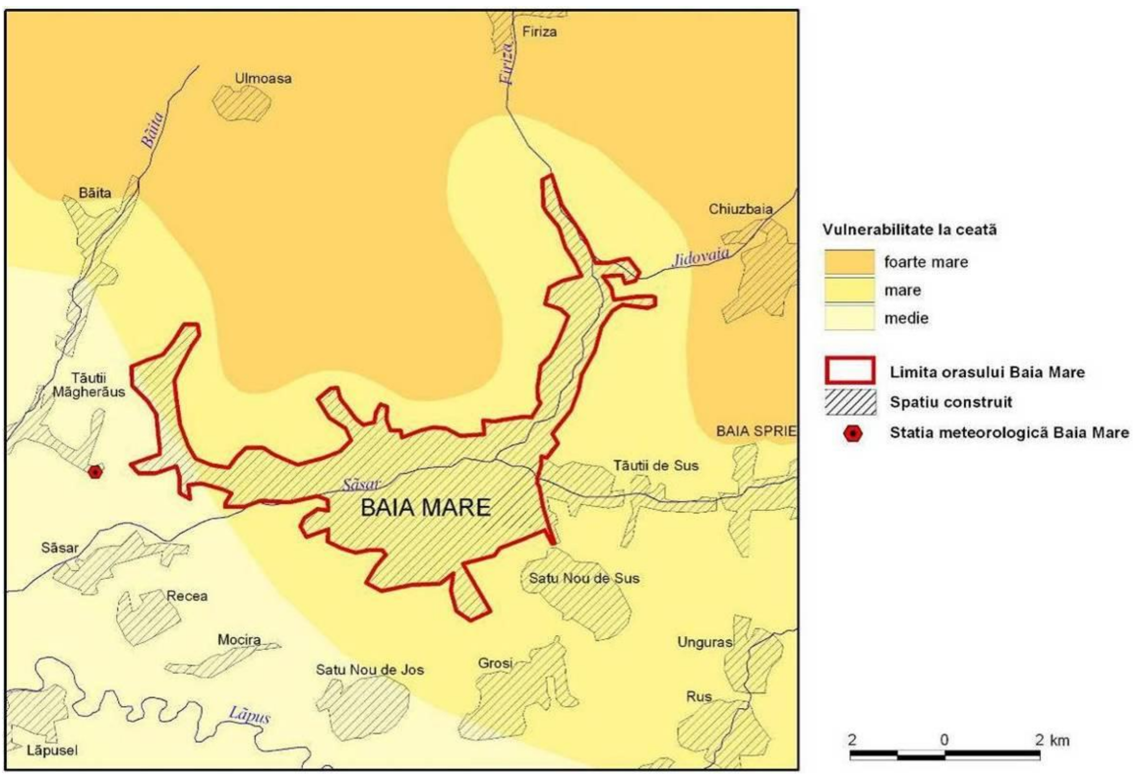


Figure 4.7 Vulnerability to fog in Baia Mare municipality's area

The thundery phenomena are associated with pouring rains. Annually, the average number of days with thunderstorms in the western extra-Carpathian regions from Romanian is between 35-40 days, reaching 37 days at Baia Mare meteorological station. In this context, Baia Mare municipality's area presents *an average vulnerability* to this dangerous meteorological phenomenon.

The fog and ***acid depositions*** represent an atmosphere’s important pollution source, through the mechanical (fog) and chemical (acid depositions) effect, having a negative impact over the environment. *The fog’s* presence regardless the shape in which it presents itself, has a negative impact over the transport activity and population’s health. The analyzed area fits the category of *extremely high vulnerability* in the north side of Baia Mare municipality’s periurban space, and *high* on the entire surface of Baia Mare city and in its surroundings and *low* in the analyzed perimeter’s south and south-west (Figure 4.7).

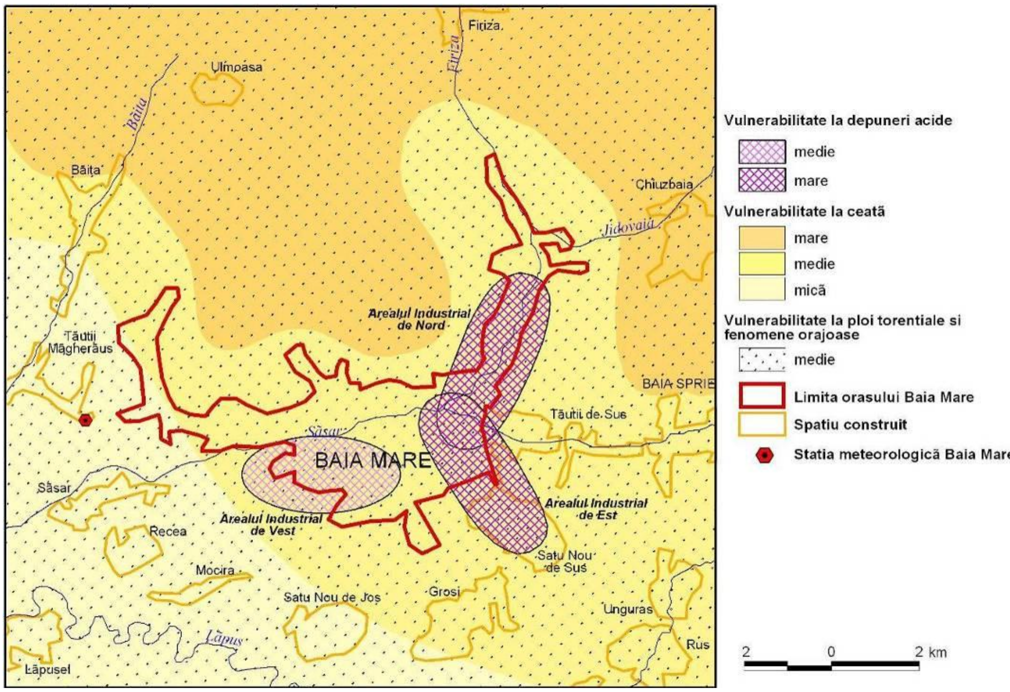


Figure 4.7 Climatic risks during the year in Baia Mare municipality’s area

CHAPTER 5

IDENTIFICATION AND ANALYSIS OF HYDROLOGICAL HAZARDS

5.1. Hydrological hazards classification

According to the definition given by Prof. V. Sorocovschi in the paper “Hydrological hazards classification. A perspective”, the hazard, a significant component of the risk notion, represents an extreme phenomenon, natural or anthropic, with a high manifestation probability in a certain territory and in a given date, with serious consequences for the environment and the human society, exceeding the security measures which this imposes. When defining the risk notion, we appeal to the second significant component, which is the vulnerability, establishing the interactions between them. Therefore, the risk expresses the occurrence probability of harmful consequences or loses, that result from the interactions between the natural or anthropic hazards and the vulnerability (UNISDR, 2003). Phenomena and risk hydrological processes’ classification can also be done according to their origin, which can be categorized as follows:

Extreme hydrological phenomena: these include floods and hydrological drought, phenomena which occur rarely and unusually.

Hydrodynamic phenomena and processes: include all air circulation forms regardless of the state of aggregation and which can generate material and human damages. In this category, the waves, floods, indrafts, fluctuation of the planetary oceanic level, icebergs, avalanches etc. are included.

The stationary hydrological phenomena and processes: those phenomena can generate material and human damages as a consequence of maintaining the water in liquid form, for an undetermined time, at surface (humidity excess, muddy discharges) or in depth (landslides).

Processes and phenomena related to hydrological disturbances: these occur both in the continental area, as well as at the contact between the continental and marine area (Victor Sorocovschi, Magazine "Riscuri şi Catastrofe", and volume 8). According to this classification, the hydrological hazards from Baia Mare municipality's area can fit in the *Extreme hydrological phenomena* group in what concerns the floods, as well as the *Processes and phenomena related to hydrological disturbances* group in what concerns the induced impact by the mining and waste waters' activities, over the Săsar basin's hydrographical network.

5.2. Hydrographical network and morphometric elements

The hydrographical system that drains Baia Mare Muncipality belongs to Someş hydrographical basin, respectively to Lăpuş feeder through the two cadastre sub-basins: Săsar (cadastral code II.1.66.19) and Craica (cadastral II.1.66.18), located at south of the first row and having quasi-parallel courses (table 5.1).

Table 5.1 The cadastre rivers from Baia Mare ATU's territory

Cadastral Code	Or	Sbh	Name of river	S_Kmp	Hmed	Pmed	L_km	Lpr_km
II_01.066.18	3	-	Craica	15.3	238.9	3.5	17.32	17.32
II _01.066.19	3	4	Săsar	309.3	642.0	16.1	106.39	30.53
II _01.066.19.01	4	-	Chiuzbaia	19.8	693.0	19.7	10.41	10.41
II _01.066.19.02	4	3	Firiza	168.2	754.4	17.5	49.39	28.03
II _01.066.19.02.01	5	-	Pistruia	10.6	910.1	16.8	6.16	6.16
II _01.066.19.02.02	5	-	Valea Neagră	23.9	838.9	18.2	7.47	7.47
II _01.066.19.02.03	5	-	Jidovaia	11.5	735.9	20.7	7.73	7.73
II _01.066.19.02a	4	-	Usturoi	11.7	458.5	17.5	5.50	5.50
II _01.066.19.03	4	-	Borcut	19.5	436.5	18.4	10.57	10.57

Or-cadastral order (1 – the main rivers from Romania; 6-the smallest cadastre rivers)

Thus, Sbh – number of cadastre hydrographical sub-basins; S_kmp – basin's surface in km^2; Hmed – the hydrographical basin's average altitude; L_km – cadastre rivers' length from the basin (including feeders) in km; Lpr_km – the main river's length which drains the respective basin.

The morphometric elements were determined based on the topographic information from the topographic maps scale 1:25.000. This information was transformed into a Land's Digital Model (LDM) with a resolution of 10 m, which also allowed a particularization in regard to the areas' cadastre basins characterized from a morphometric perspective, particularization imposed by the analyzed surface (city's urban area). Based on the LDM, the number of cells which makes the accumulation (FAC – flow accumulation) is generated. Practically, the number of cells from upstream which makes the hydrographical basic up to that point is generated for each cell (Figure 5.2). Using the LMD's cell dimensions, the hydrographical basins' surface is generated. The hydrographical network and its related basins were generated based on this, with the condition that the accumulated surface to be of a minimum of 0, 5 km^2. However, each basin is characterized also by the complete discharge course (between the basin top and the basin exit point).

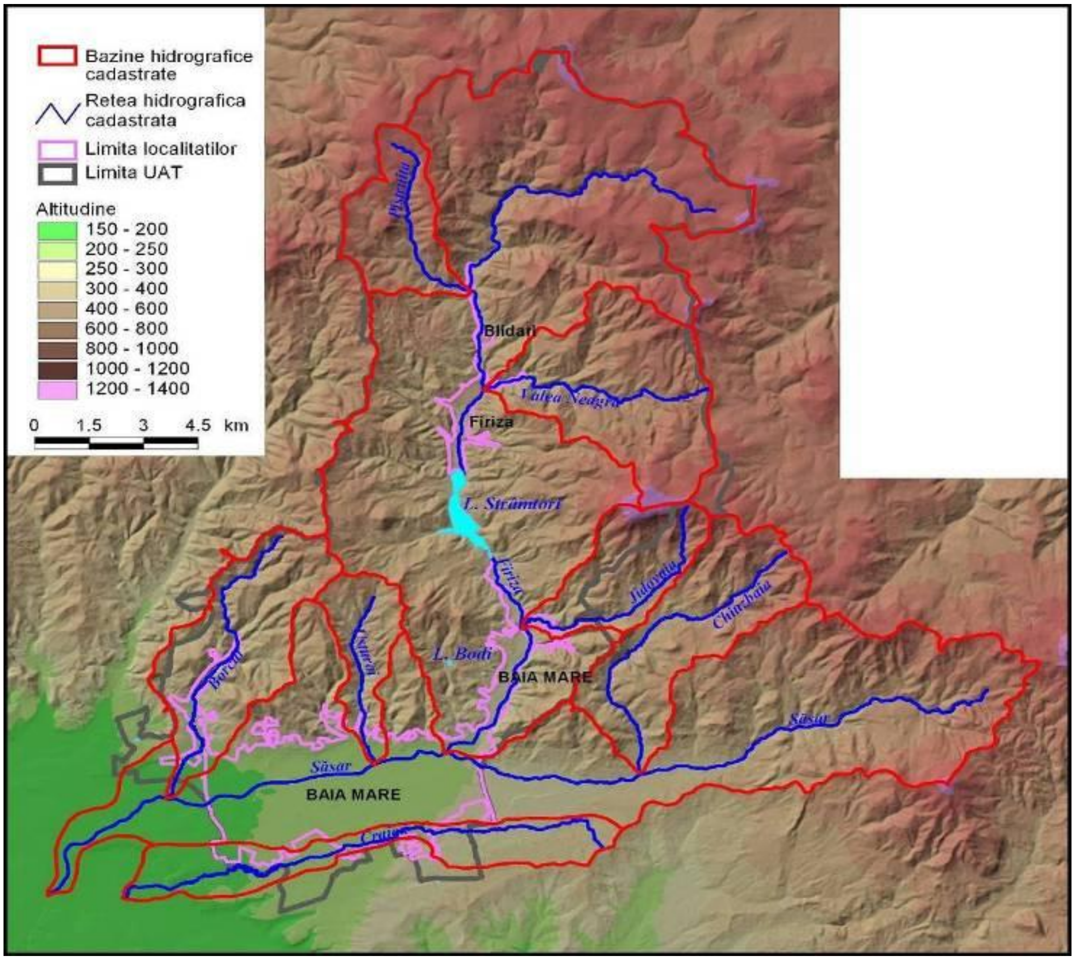
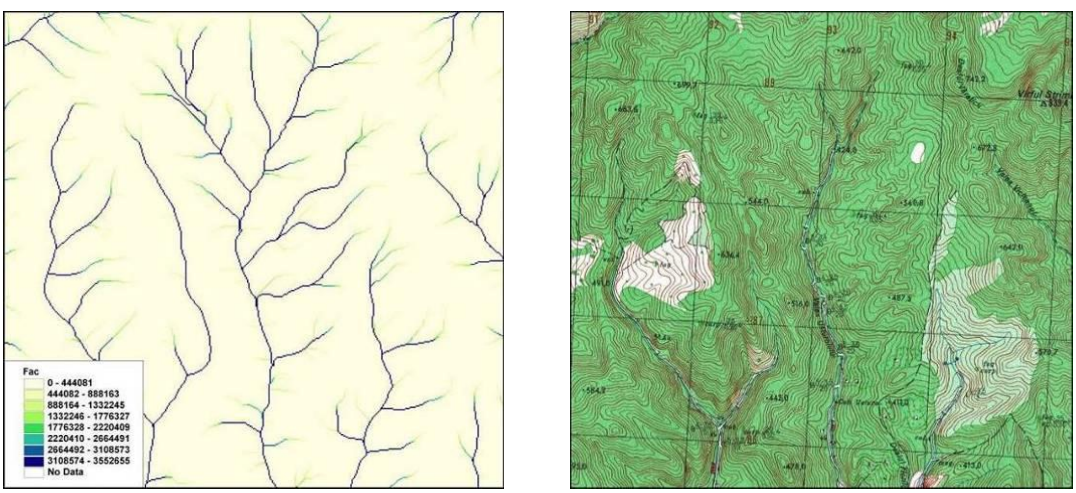


Figure 5.1 – Cadastre hydrographical system from Baia Mare ATU's territory



a) **b)**

Figure 5.2 –Hydrographical network generation based on the LDM (a) in comparison with the hydrographical network on the topographic maps (b)

Both for the morphometric characterization as well as for the highest discharges calculus, 24 hydrographical areas (units) were established, both basins and sub-basins as well as inter-basin surfaces, to which two points on Săsar are added inside the locality which each cuts-off two. As cutting-off points of the hydrographical system specific to Baia Mare urban area were found: Săsar at the confluence with Firiza and Firiza downstream dam Strâmtori.

For each unit, it was determined: the surface (km^2), the average altitude (m), the average slope (degrees), the forestation coefficient (%), the shape coefficient depending on the basin's perimeter and the shape depending on the basin's length. These parameters were initially determined for each unit (partial surfaces) and in the end, accumulated for each hydrographical units' cutting-off point (table 5.2).

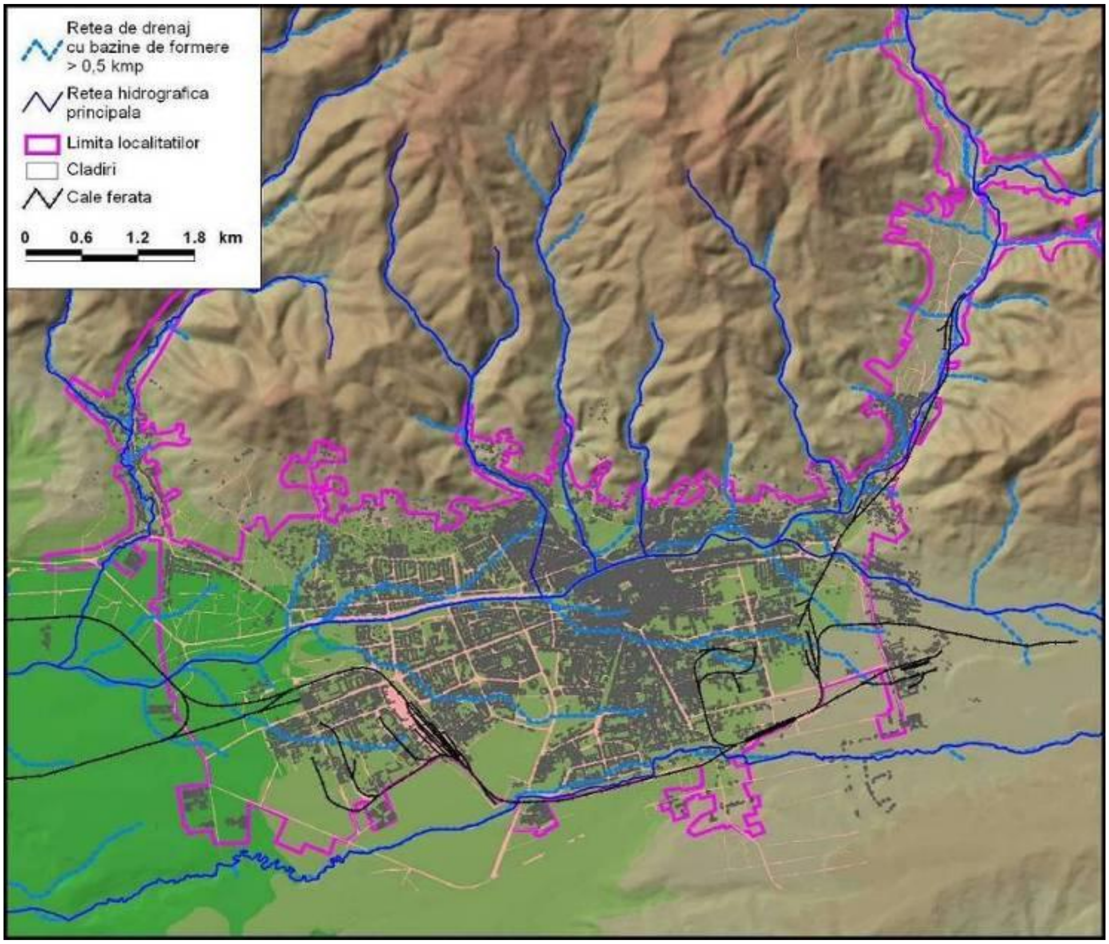


Figure 5.3 – Natural draining off network specific to Baia Mare city

Table 5.2 Morphometric characteristics of hydrographical units

Running Number	Name	Upstream point	Downstream point	Name of sector	Bh cumulate						
					S (km^2)	**L flow (km)**	**Hmed (m)**	**P med (^{0})**	**Cc**	**Cf**	**Cp**
1	Săsar	Headwater	Firiza	Săsar upstr. Firiza	73.00	19.14	652.8	16.5	0.26	0.25	71.5
2	Firiza	Headwater	Firiza dam	Firiza upstr. Firiza dam	133.56	22.54	799.3	17.1	0.34	0.33	93.4
3	Firiza	Firiza dam	Jidovoaia Valley	Firiza upstr. Jidovoaia Valley	141.22	25.11	781.9	17.1	0.33	0.29	93.0

4	Jidovoaia Valley	Headwater	Firiza	Jidovoaia Valley	11.66	8.08	728.1	20.8	0.34	0.23	76.9
5	Firiza	Jidovoaia Valley	Vicleanul Mare	Firiza upstr. Vicleanul Mare	164.00	29.62	751.8	17.4	0.30	0.24	90.6
6	Vicleanul Mare	Headwater	Firiza	Vicleanul Mare	3.62	5.43	505.5	21.4	0.21	0.16	97.7
7	Firiza	Vicleanul Mare	Săsar	Firiza upstr. Săsar	168.57	30.50	743.8	17.4	0.32	0.23	90.4
8	Săsar	Firiza	Sf. Ioan	Săsar upstr. Sf. Ioan	245.45	20.85	709.5	17.0	0.25	0.72	83.7
9	Sf. Ioan	Headwater	Săsar	Sf. Ioan	2.54	4.50	431.8	18.6	0.28	0.16	94.6
10	Săsar	Sf. Ioan	Usturoi Valley	Săsar upstr. Usturoi Valley	248.23	21.44	706.2	17.0	0.24	0.69	83.8
11	Usturoi Valley	Headwater	Săsar	Usturoi Valley	7.69	6.99	469.9	17.7	0.25	0.20	92.0
12	Săsar	Usturoi Valley	Roşie Valley	Săsar upstr. Roşie Valley	260.39	22.08	691.3	16.8	0.25	0.68	82.6
13	Roşie Valley	Headwater	Săsar	Valea Roşie	5.73	6.80	462.1	20.8	0.24	0.16	89.5
14	Săsar	Roşie Valley	intermediary point BM	Săsar BM1 upstr. intermediary point	4.61	2.97	282.1	9.0	0.47	0.66	18.6
15	Săsar	Roşie Valley	intermediary point BM	Săsar BM2 upstr. intermediary point	4.99	2.97	219.0	0.8	0.27	0.72	0.0
16	Săsar	Roşie Valley	intermediary point BM	Săsar upstr. intermediary point BM	275.72	25.05	671.2	16.4	0.25	0.56	80.2
17	Săsar	intermediary point BM	Borcut Valley	Săsar BM3 upstr. Borcut Valley	3.63	2.75	221.5	3.7	0.38	0.61	2.0
18	Săsar	intermediary point BM	Borcut Valley	Săsar BM4 upstr. Borcut Valley	4.96	2.75	201.7	0.8	0.30	0.84	0.0
19	Săsar	intermediary poit BM	Borcut Valley	Săsar upstr. Borcut Valley	284.32	27.80	657.2	16.0	0.24	0.47	77.8
20	Borcut Valley	Headwater	Bartoşa Valley	Borcut Valley upstr. Bartoşa Valley	3.88	5.49	534.2	22.8	0.23	0.16	100.0
21	Bartoşa Valley	Headwater	Borcut Valley	Bartoşa Valley	3.14	4.24	553.7	20.5	0.29	0.22	100.0
22	Borcut Valley	Bartoşa Valley	Frumuşaua	Borcut Valley upstr. Frumuşaua	13.30	8.46	478.1	21.8	0.32	0.24	97.2
23	Frumuşaua	Headwater	Borcut Valley	Frumuşaua	2.67	4.51	375.7	17.1	0.26	0.17	90.2
24	Borcut Valley	Ţigher Valley	Săsar	Borcut Valley upstr. Săsar	18.68	11.87	434.0	19.4	0.26	0.17	84.8
25	Săsar	Borcut Valley	Someş	Săsar upstr. Someş	312.89	33.05	628.8	15.7	0.21	0.36	75.8
26	Craica	Headwater	Lăpuş	Craica	14.41	16.24	243.0	2.1	0.13	0.07	0.0

Where, L_flow – the draining off line's complete length in km; Hmed – the hydrographical basin's average altitude Pmed – the hydrographical basin's average slope; CC – circulation coefficient; Cf – shape coefficient; Cp – forestation coefficient.

The circulation coefficient (C_c) is determined as a proportion between the basin's surface (S_b) and the circle's surface, which has the same girth length as the basin's perimeter (S_c). Although the perimeter's length depends a lot on the sweep degree of the basin's limit, this coefficient offers a better image over the basin's circulation, when it gets near to the 1 value, or of an extension, when it tends to 0. In the Romanian literature, a **shape coefficient (C_f)** developed by Diaconu and Lăzărescu in 1965, is used a lot. This coefficient can vary between 0 and 1 (the coefficients that tend to 0 indicate lengthened and much lengthened basins, and those that tend to 1, circular basins) and is used, especially for the correlation and regionalization of highest discharges and of certain high floods' elements, these presenting a weak correlation with the altitude.

5.3. The hydrological regime

For the average discharges and the hydrological regime's analysis a minimum of 25 years is necessary, their characteristics remaining constant throughout the time. Even if some extreme values appear, it is less probable that these will modify the hydrological regime's general characteristics. In the Săsar river's basin, analyzing the data from the 1971-2000 period, a common feature is noticed for all hydrometric stations: the year period when the highest average discharge is registered, is the one from the spring-summer beginning, with a maximum in the month of April. The second increase, although of a lesser ampleness in regard to the previous period, is characteristic to the autumn's end and the winter's beginning, with a maximum in the month of December (Figure. 5.7). The multiannual average discharge is of 6, 04 m^3/s, the basin's surface in the station's section being of 266 km^2.

Săsar river's basin category corresponds to the *west Carpathian type*, characterized by large spring waters (March-April) and high floods in the other seasons. The minimum discharge is characteristic to the autumn period. At Baia Mare station, the minimum value is registered in the month of September. The monthly values' fluctuation for this indicator can be observed in (Figure 5.8). The average minimum discharge at Baia Mare station of Săsar is of 1,951 m^3/s, the lowest value being registered in the year 1984 (1, 12 m^3/s), and the highest value in 1988. Firiza river is characterized through a multiannual average discharge of 2, 44 m^3/s at Blidari station (The basin's surface is of 68 km^2) and 4, 20 m^3/s at Friza station, upstream from the confluence with Neagra Valley.

5.4 Extreme hydrological hazards – floods

5.4.1 Highest discharges with 1% probability. The highest discharge is of great interest from a practical perspective, this being taken into account when establishing the areas that present a risk to floods, design, performance and exploitation of defence works against floods (dams, polders, dammed in buildings etc.) as well as of other hydrotechnical construction, of bridges etc. Lessening the generated risk by large waters through flooding some unprotected areas or through the behaviours during these extreme events of the performed establishments, is not possible without a good analysis of this discharge type.

Geographical factors that determine the highest discharge. Precipitation, through the maximum quantity, intensity and duration, due to the mountainous terrain located in the close northern vicinity, registers high values; these can annually exceed even 1100 mm. The maximum precipitation quantities' highest values fallen in 24 hours occur in the May-October period. Their monthly average reaches the highest values in the month of August (60.2 mm). The absolute maximum quantity registered 121.4 mm/13.05.1970. From the thundery highest amount of precipitation's zoning perspective with 1% probability, for Baia Mare area, the value is of 125 mm, being gradually lessened towards west, at the confluence of Săsar with Lăpuş, this being of 115 mm. The discharge coefficient is of 0, 4-0, and 5.

Both the soils, especially their texture, as well as the playgrounds' usage method, play an important role in the formation of discharges, especially of the maximum liquid ones. Usually, their role is believed to be combined, thus, being developed by a series of indicators to reflect the discharge coefficient (as a proportion between the leaked water layer and the fallen rain layer) in regard to the two factors. So, the determination's physiographical method of the highest discharges is based on the CN index usage (Curve Number) from the SCS model. The CN index is adimensional and can take values between 0 and 100. CN depends on both the land's usage as well as the soil's hydrological group and reflects the water's discharge potential on different lands (Chendes, 2007, Drobot and Chendes, 2008).

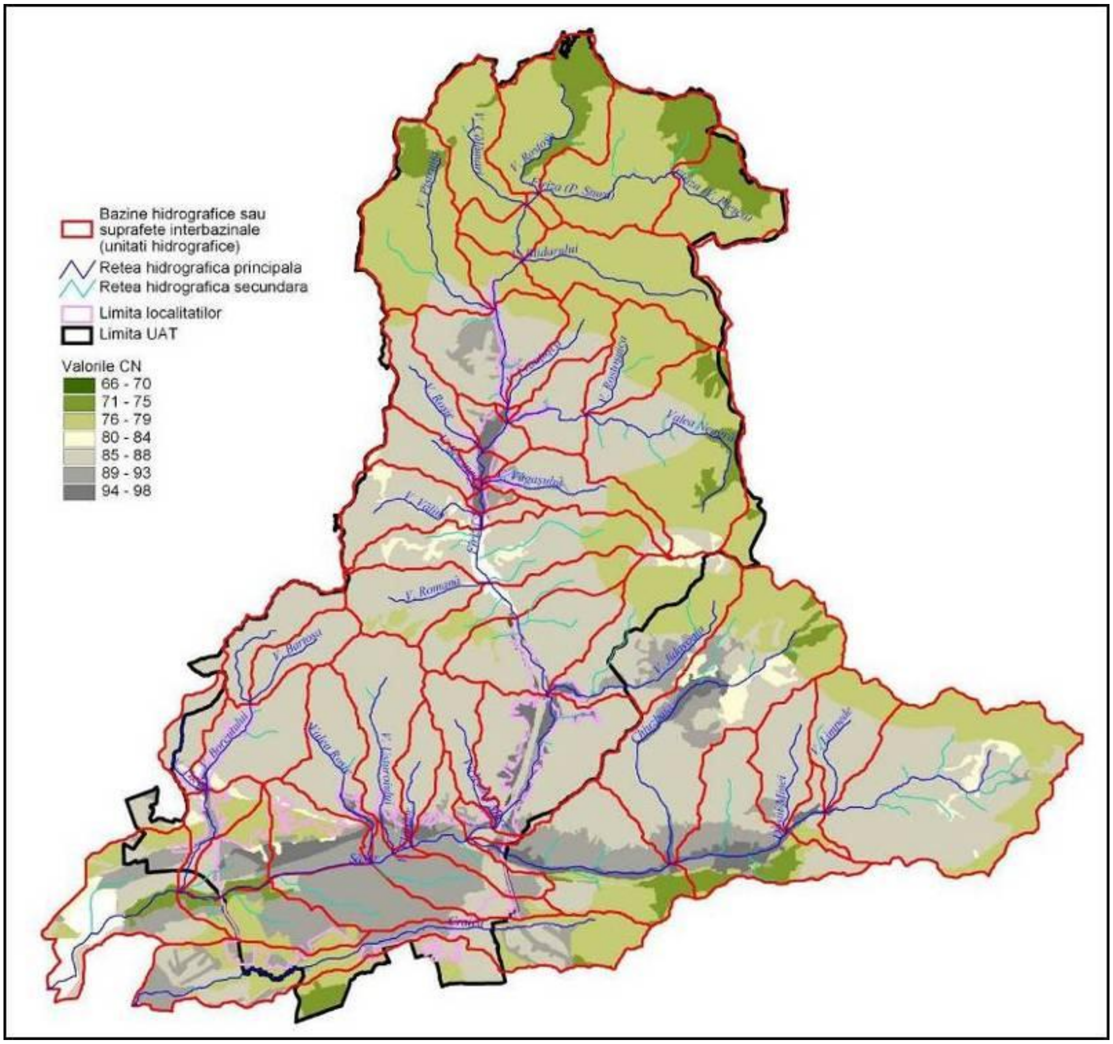


Figure 5.4 CN coefficient's fluctuation depending on soils and vegetation

The highest discharges also depend on the main channel's length and the basin's slope, these two parameters being used for the concentration time's calculus T_c (defined as the longest time when a drop of water which falls in a basin reaches the exit or the time that passes between the end of the rain and the crippling point's occurrence on the hydrograph's descending curve) and the delay time T_{LAG} (the time that passes between the rain's interval center and the moment when the high flood's acme occurs).

$$T_{LAG} = (3{,}28084 * L)^{0{,}8} * \frac{(S+1)^{0{,}7}}{1900\sqrt{I_B}} \qquad T_C = 1{,}6667 * T_{LAG}$$

Where: T_C – concentration time in hours; T_{LAG} – delay time in hours;

L – the main channel's length in m;

I_B – basin's average slope in %;

$S = \frac{1000}{CN} - 10$ and represents the maximum retention in basin.

Table 5.4 The retention water maximum capacity from the precipitation in the basin

Running Number	Name	S (mm)
1	Săsar upstr. Firiza	47.6
2	Firiza upstr. Firiza dam	58.3
3	Firiza upstr. Jidovoaia Valley	57.6
4	Jidovoaia Valley	50.3
5	Firiza upstr. Vicleanul Mare	55.7
6	Vicleanul Mare	44.0
7	Firiza upstr. Săsar	55.3
8	Săsar upstr. Sf. Ioan	52.6
9	Sf. Ioan	43.3
10	Săsar upstr. Usturoi Valley	52.5
11	Usturoi Valley	43.2
12	Săsar upstr. Roşie Valley	51.8
13	Roşie Valley	42.3
14	Săsar BM1 upstr. intermediary point	39.7
15	Săsar BM2 upstr. intermediary point	27.9
	Săsar upstr. intermediary point BM	50.9
16	Săsar BM3 upstr. Borcut Valley	52.1
17	Săsar BM4 upstr. Borcut Valley	48.8
	Săsar upstr. Borcut Valley	50.9
18	Borcut Valley upstr. Bartoşa Valley	44.8
19	Bartoşa Valley	44.8
20	Borcut Valley upstr. Frumuşaua	44.7
21	Frumuşaua	44.6
22	Borcut Valley upstr. Săsar	45.7
23	Săsar upstr. Someş	50.6
24	Craica	48.8

For Săsar upstream from the confluence with Firiza, a discharge of 165.3 m^3/s was determined, so that after the confluence with Firiza to increase to 314.1 m^3/s. At the exit from the city, upstream from Borcut Valley, the discharge values of 1% reach 339.4 m^3/s. The small valleys from north of the city have the highest discharges between 25 – 80 m^3/s, instead, being small basins, of pouring type, they are characterized through specific discharges close to or even over 1000 $1/s/km^2$ (10326 $1/s/km^2$ for Sf. Ioan b.h.)

Table 5.5 Determined highest discharges , with 1% probability

Running number	Name of river	Name of sector	S (km^2)	Hmed (m)	Q (m^3/s)	q ($l/s/km^2$)
1	Săsar	Săsar upstr. Firiza	73.00	652.8	165.3	2264.8
2	Firiza	Firiza upstr. Firiza dam	133.56	799.3	227.7	1704.5
3	Firiza	Firiza upstr. Jidovoaia Valley	141.22	781.9	234.5	1660.3
4	Jidovoaia Valley	Jidovoaia Valley	11.66	728.1	61.9	5312.8
5	Firiza	Firiza upstr. Vicleanul Mare	164.00	751.8	253.8	1547.4
6	Vicleanul Mare	Vicleanul Mare	3.62	505.5	32.2	8913.6
7	Firiza	Firiza upstr. Săsar	168.57	743.8	257.5	1527.4
8	Săsar	Săsar upstr. Sf. Ioan	245.45	709.5	314.1	1279.5
9	Sf. Ioan	Sf. Ioan	2.54	431.8	26.2	10326.0
10	Săsar	Săsar upstr. Usturoi Valley	248.23	706.2	315.9	1272.8
11	Usturoi Valley	Usturoi Valley	7.69	469.9	49.3	6412.2
12	Săsar	Săsar upstr. Roşie Valley	260.39	691.3	324.0	1244.4
13	Roşie Valley	Roşie Valley	5.73	462.1	41.9	7302.9
14	Săsar	Săsar BM1 upstr. intermediary point	4.61	282.1	37.0	8032.3
15	Săsar	Săsar BM2 upstr. intermediary point	4.99	219.0	38.7	7759.4
	Săsar	Săsar upstr. intermediary point BM	275.72	671.2	334.0	1211.3
16	Săsar	Săsar BM3 upstr. Borcut Valley	3.63	221.5	32.3	8896.9
17	Săsar	Săsar BM4 upstr. Borcut Valley	4.96	201.7	38.6	7777.7
	Săsar	Săsar upstr. Borcut Valley	284.32	657.2	339.4	1193.9
18	Borcut Valley	Borcut Valley upstr. Bartoşa Valley	3.88	534.2	33.6	8648.3
19	Bartoşa Valley	Bartoşa Valley	3.14	553.7	29.7	9456.3
20	Borcut Valley	Borcut Valley upstr. Frumuşaua	13.30	478.1	66.5	5002.1
21	Frumuşaua	Frumuşaua	2.67	375.7	27.0	10121.1
22	Borcut Valley	Borcut Valley upstr. Săsar	18.68	434.0	79.9	4279.3
23	Săsar	Săsar upstr. Someş	312.89	628.8	357.1	1141.2
24	Craica	Craica	14.41	243.0	69.5	4822.2

5.5. Hydrological hazards analysis

To determine the highest discharges' corresponding levels with 1% probability, 15 transversal profiles on cadastre rivers from the city area were performed, as well as on the small valleys located in the north of the city, as follows: 3 transversal profiles on Borcut Valley; 4 transversal profiles on Craica; 1 transversal profile on Vicleanul Mare; 1 transversal profile on Sf. Ioan; 2 transversal profiles on Usturoi Valley; 2 transversal profiles on Roşie Valley; 2 transversal profiles on Săsar.

On Firiza river, the discharges not being anymore in natural regime, the flooding studies reported at the natural regime discharge are not significant anymore (Figure 5.5).

Borcut Valley – upstream. The right shore is represented by an over raised road and is not affected by the 1% discharge. The left shore, a little more depressed, can be affected by a discharge occurrence calculated with the 1% probability. The expected water slide, in this case, would be of a maximum of 50 cm.

Borcut Valley – upstream Frumuşaua. Most probably, the gazing land behind the left shore is floodable at 1%; currently, the filling made when the house was built, just in front of the profile, is at the security limit for the calculated discharge in this study. In respect to the grazing land sector from the right side, this is located at a lower height with almost 0, 5 m in comparison with the left shore.

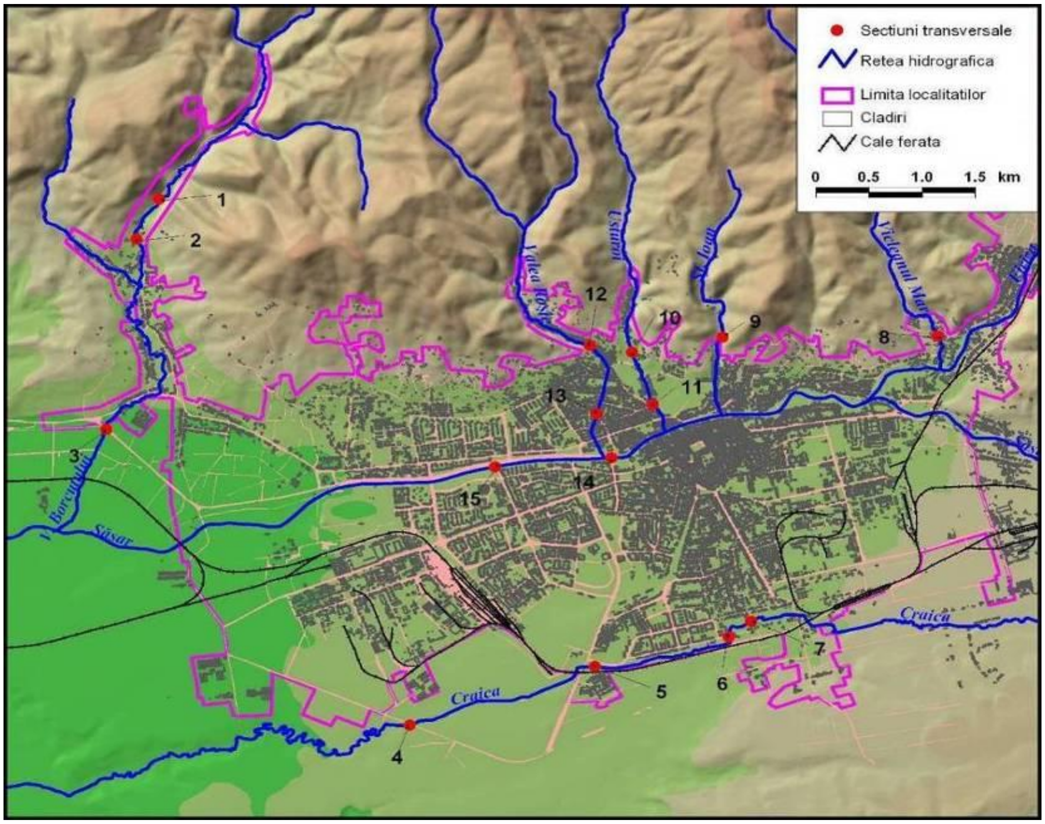


Figure 5.5 Transversal profiles made for flooding evaluation

Borcut Valley – DN 1C Baia Mare – Satu Mare (Figure 5.22 – 23-24-25). It is a very low area, the interfluve between Borcut Valley and Săsar having a NW-SE dip, towards the collector river, however, the slope on this plain's complex being very small. The right shore, higher, is located a lot over the related discharge level 1%. The left shore, however, is a little lower, thus, it can be affected by the next extreme events with lower probabilities of 1%. This area between the two mentioned valleys can be seen as a floodable area which is important in case some natural disasters occur.

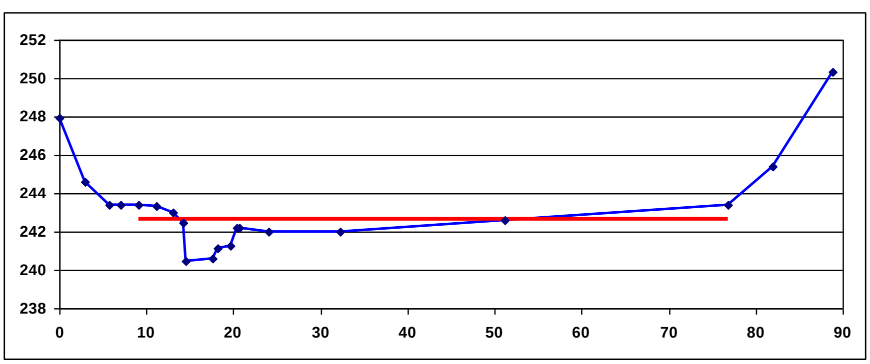


Figure 5.6 Profile 1

Craica – industrial road (Figure 5.26 – 27-28-29). This river's course crosses Baia Mare depression area, the land between Craica and Săsar being characterized by slopes and extremly low level differences. We appreciate that this footbridge can be conveyed through only by almost ¼ from the highest discharge with 1% probability.

Craica – Jandarmeria Street (Figure 5.30 – 5.37). It is a well gauged and designed channel. The floods that occurred in this area are, perhaps, due to some bridges and footbridges' blocking from upstream.

Craica – natural section upstream from V. Alecsandri district (Figure 5.42 – 5.44). Craica river's minor channel is a little deep in this sector, the low bordering areas, especially the grazing land located on the left side, unprotected, being able to be flooded at extreme events.

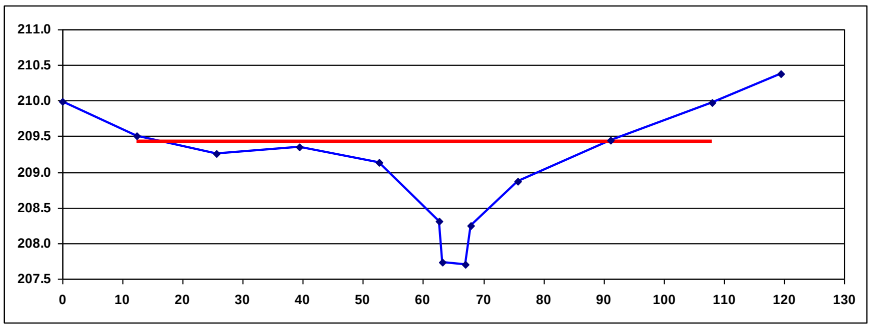


Figure 5.7 Profile 7

Vicleanul Mare Valley (Figure 5.8 – 5.9). It is a mountainous typical valley, deep enough, and especially with high slopes (5.9% of the analyzed section), which makes that the discharge conveyed through the channel to be significant. Yet, for the 1% discharges, the water can pass through to the left shore, flooding the housing area.

Sf. Ioan Valley (Figure 5.10). This valley's high slope, even after it enters on the urban area's territory (the biggest from the small valleys at north of Baia Mare) determine a large discharge capacity. In the concreted section from the built space, roughness is lessened.

Figure 5.8 Vicleanul Mare

Figure 5.9 Vicleanul Mare

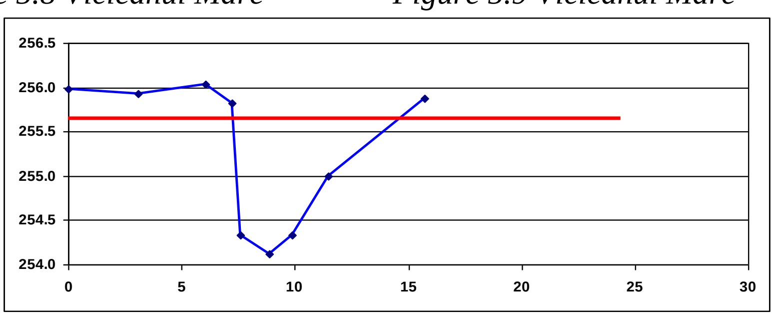


Figure 5.10 Profile 9

Usturoi Valley – parking (Figure 5.11 – 5.12). The low areas from this valley's both shores, including the road along the valley, are vulnerable to events with low probability. Besides the relatively low channel's transport capacity, it is added the footbridges' low section from this sector which lessens a lot the channel's area, but can also form favouring factors for blocking with trees' blocks, rock etc.

Figure 5.11 Low footbridges

Figure 5.12 Low footbridges

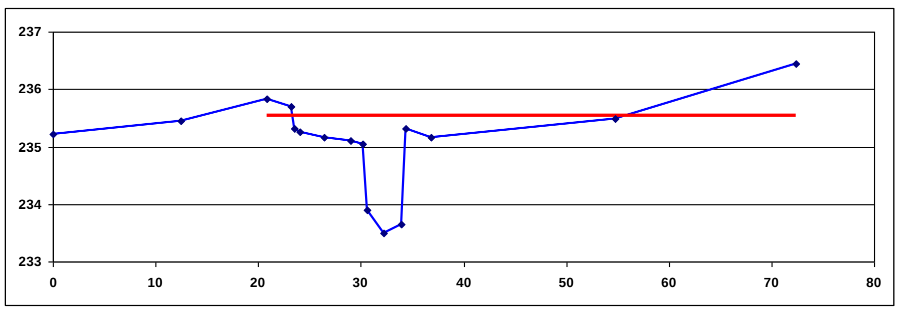


Figure 5.13 Profile 12

Săsar river – bridge House of Culture (Figure 5.15). Săsar's channel in this section shifts the 1% discharge. In landscape regime, Firiza being controlled by Strâmtori dam, perhaps, the discharge is even lower. Both Firiza and Săsar come into discussion just in case of discharges with a probability smaller than 1% (for example once at 500 or 1000 years) or in case of Strâmtori - Firiza dam's break down. For these details, further additional studies would be necessary.

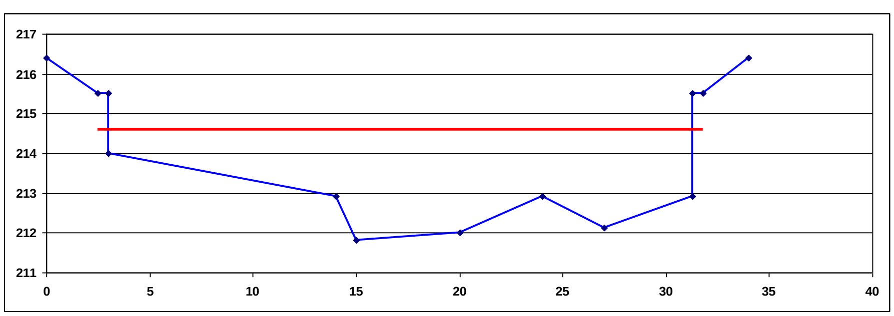


Figure 5.15 Profile 14

Săsar river – bridge County Hospital (Figure 5.16). Săsar's channel in the section – dam County Hospital presents almost the same characteristics as the previous one.

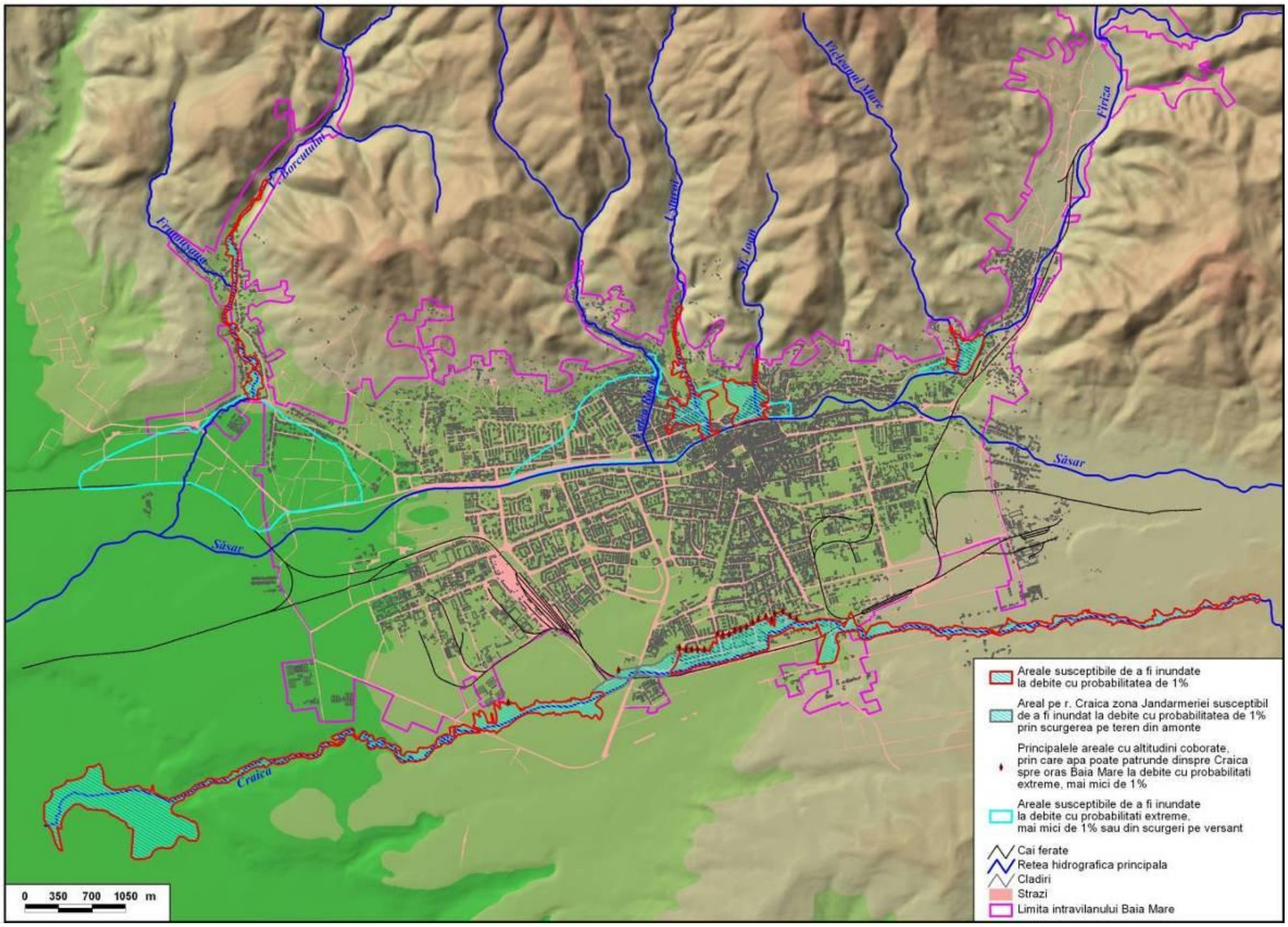


Figure 5.16 Map with floods risks with a probability smaller than 1% in Baia Mare municipality

5.6. Phenomena and processes related to hydrological disturbances

5.6.1 Conceptual Aspects; Methodology; Legislation

The hydrological disturbances represent the inflowing of some foreign water quantities in the natural waters, which make the respective waters to be ill-suited for use due to the pollution with pollutant substances, or can determine changes at the chemism level (Mioara Chiaburu-M. Dulgheru).

The river's water chemism is determined by the substratum's characteristics imprint and is influenced by hydrological, climatic and morphologic particularities of the lands from where rivers collect their waters (Sorocovschi, 2005, 2007). The natural processes can temporarily and spatially modify the usual rivers' water parameters, however, most of the times, the negative hydrological disturbances are induced by human activities, through different pollution sources (Vigh and the collaborators, 2007). The natural pollution induces a hydrological disturbances' risk due to contamination's mobility through natural processes. The negative hydrological disturbances due to these usually occur in the following conditions:

- *when travelling the waters through areas of soluble rocks (radioactive rocks, sulphate etc.).*
- *when surface waters pass through areas with soil erosion phenomena.*

Evaluating the hydrological disturbances' induced risk through an integrative concept was developed by Westrich and Forstner 2007, who display interdisciplinary approaches deviated from the water's qualitative state as well as from the deposits and pollutants' mobility in rivers' dynamic. The most common pollution sources include: industrial, agricultural, household, municipal wastes and reach into the water through: discharges, oozes, direct infusions, the contamination's course and transport having a complex network (Heise et al, 2004).

Methodology: To determine the risk, the following situations are taken into account:

- polluted if the water body subject to risk is of at least 20% from the monitoring points' total number, given the condition to respect the minimum representation indicator.
- not polluted if from the monitored points' number, the number of those polluted is smaller than 20%.

In case of subterraneous waters, if there are pollution sources at surface, we move to the evaluation of the global protection level by taking in consideration two essential parameters: *lithology* and *ooze level*. The substances' quantity reached through ooze, as well as their development in the subterraneous water depend on the soil's properties: texture, porosity, permeability, attenuation capacity (Mioara Chiaburu-M.Dulgheru). Based on the covering layers' lithological characteristics, the following protection categories are distinguished: *favourable (F); average (M); unfavourable (U)* (www.htpp.apecrisuri.ro). Depending on these parameters and the possible combinations, the global protection's value chart of a subterraneous body can be determined. The physic-chemical indicators were analyzed in conformity with the Water's Framework Directive and the Methodological Guide's provision included in the order 161/16.02.2006 concerning the regulatory's approval to classify the surface waters' quality and in conformity with order 137/26.02.2009 concerning the natural capital's values approval, threshold for subterraneous water bodies.

5.6.4 Disturbance between the mining activity and rivers

The pollution that comes from raw metals' exploitation mines was and still is neglected. It is often thought that, when the mining activity stopped, the pollution problems disappeared. For this reason, the abandoned mining points are potential sources for rivers' pollution. The waters that come from mining roadways from Baia Mare municipality's area cover the perimeter's metalogenetic district, from a geological perspective. In this respect, some lands were analyzed, such as: Săsar, Crucii Hill and Herja through a series of waters' qualitative indicators.



5.6.5 Water's disturbance that comes from ponds and waste heaps with the hydrographical network

In the deposits' valuing process, a useful mineral substance and an unuseful gangue material result. The useful substances represent only 0,3 – 0,4 % from the drawn raw material's total mass, thus, the gangue quantities are very important. Formed on volcanic rocks, usually weatherworn, they carry poor raw materials, with a low useful content. On Borcut Valley, there is a complex of 6 small inactive heaps. Usually, they are not designed properly, being placed on flanks, without building some adequate dams or sewages for waters' quality protection. The largest gangue quantity, however, results from the processing activity of non-ferrous raw materials, with weak contents of Cu, Pb, Zn, Au, Ag, sulphates, iron oxide, and neosyl. Therefore, 80% from gangue result from the raw material's processing, the rest coming from drawing. In Baia Mare area there are 4 sedimentation ponds: Bozânta, Baia Sprie, Flotaţia Centrală and Săsar which were analyzed in this paper. Currently, they are under preservation.

5.6.7. The hydrological disturbance between the phreatic waters and the biological, chemical, physic-chemical quality elements

The phreatic waters quality's characterization from the main investigated bodies is based on the general indicators' analysis which makes reference to the natural regime of subterraneous waters' chimism and to the specific indicators present due to some pollution sources.

To evaluate the chemical state of subterraneous waters' bodies, many phases were covered. For metals, organic micro-pollutants and non-primary specific pollutants, that have values Maximum Admissible Concentration in law 458, the determined values were compared with the admissible concentrations from the environment's quality standards (Directive No. 105/2008/CE and Government Decision No. 351/2005). For PCBs (polychlorinated biphenyls) a comparison limit was established according to a study by The National Institute of Research and Development for Environmental Protection.

CHAPTER 6

PREVENTION, DIMINISHING AND REFUTAL OF GEOMORPHIC, CLIMATIC AND HYDROLOGICAL HAZARDS

6.1. Theoretical and legislative recitals

Risks management includes more phases, each having specific actions. Risks prevention represents the first phase, when many actions are taken, to which, currently, a special attention is given to because they are thought to be the main method through which the crisis' management progresses. The actions through which a crisis' prevention is made were included by Levèfre and Schneider (2002) in different levels: hazards and vulnerability's evaluation, information methods, population training and education in respect to risks, risks' prevention and lessening through designs that lessen vulnerability, crisis preparation by developing surveillance networks and by elaborating emergency plans which are tested before the crisis.

Prevention measures' goal is to lessen the risk; and they are materialized through structural and unstructural interventions. The firsts, through active or passive systematization work, tend to lessen the event's nuisance, lessening the occurrence probability and/or minimizing its consequences.

Through the unstructural interventions, the risk's lessening is still assigned to the risks elements and their vulnerability's decreasing. Broadly speaking, unstructural interventions can make reference to prevention activities, while the structural interventions are specific to the risks' lessening activities (Sorocovschi V.).

According to Alexander (2004), the non-structural interventions can be of a short term (emergency plans, evacuation plans, impact prevention, alert mechanisms) and of a long term (construction's codes and regulations, danger's macrozonation, control of land's usage, risk's statistical analyses, insurances, taxes, education and training). In the structural measures category, the following are included: the existing structures' reaccomodation, strengthening the new structures, security elements, probabilistic prevention for resistance at impact etc. The natural risks' prevention mechanism consists of taking complex measures destined to limit and reduce the damaging effects. This mechanism assumes more phases in which the scientific research, the public, political and media local authorities directly cooperate (Sorocovschi V).

6.2. Prevention, diminishing and refutal of geomorphic risks

These measures were taken in conformity with "The guide concerning the landslides' identification and monitoring and establishing intervention framework solutions, in order to prevent and lessen their effects, for the buildings' security in exploitation, the environment's recovery and protection" – indicative GT 006-97 ISPIF – SA Bucharest.

Besides the rocks' physical and mechanical characteristics' influence and the flanks' geomorphologic particularities, the landslides' triggering depends on the vibrations' acceleration.

Defence unstructural measures against landslides. We mention:

a. Flanks' microzonation from the perspective of risk to landslide.

b. The slide areas' identification and research and of those with landslide potential.

c. Landslides' monitoring

c.1. following the landslides' evolution through topographic measurements.

c.2. measurements with the flexible tablature.

c.3. other equipments for registering the effort state from the flanks and the landslides' evolution (extensometers with vibratory chord, tachometers, detecting elements for interstitial pressure's measurement, open pyrometers and so on).

d. Methodology concerning the stability evolution's identification to prevent landslides. Knowing the dislocation cripplings occurred in the phase after landslides using "periodic observation stations of the cripplings" allows identifying the flanks and slopes stability's evolution, as a starting point for landslides prevention.

e. Intervention framework solutions in order to prevent and reduce the landslides' effects for buildings' exploitation security, the environments' recovery and protection.

The usual solutions for landslides' prevention and stability can be schematically grouped in three categories:

- flanks' surface design;
- buttress works;
- subterraneous water draining off works.

Defence structural measures against landslides

Buttress works. The main support work types adopted to stabilize the landslides are:

Buttress walls. These are weight works that are performed in order to take over the dislocations resulted from the slide mass' displacement to protect certain buildings. The buttress walls are made in case of relatively low landslides, usually up to 5, 00 m.

Reinforcements with buttress arches. These buildings are made of concrete bulks grated directly on the durable lands or through piles, pillars or bars, between which masonry arches or from concrete are made through which the land from the landslide is pushed.

Buttresses with piles, pillars or bars. In case of some landslides with a big thickness, buttresses made of ferro-concrete piles, pillars or bars is adopted, embedded in the durable rock and solidified at land's surface through ferro-concrete beams.

Buttress through braces. Such buttresses are applied for small developed landslides' areas, especially for cliffy, rifty rocks.

Draining the subterraneous water. The water's draining off solutions from the flanks are diverse, depending on the landslides' characteristics. The most used are:

Drains in the shape of channels filled with gravel.

Draw wells networks with connection drains.

Roadways with discharge soil logs.

Superficial drains, in the shape of channels filled with gravel.

Horizontal drains in shape of ear.

Flexible filiform geodrains.

Protection and intervention rules. Depending on the landslides' occurrence potential, the legislator set up some intervention and protection rules (Ministry of Public Works and Territorial Arrangement Order 62/N/1998), as follows:

a) for the area with a low landslide potential

b) for the area with an average landslide potential (buildable with a geotechnical location expert opinion)

c) for the area with a high landslide potential

6.3. Case studies – Technical solutions for Dura landslide stabilization. For the complex analysis of this area, the following favourable factors of the landslide's triggering/reactivation are analyzed:

Condition factors

- **Geological layer**
- **Physic-mechanical characteristic**
- **Terrain's morphology and morphometry**
- **Local hydrogeological conditions**

Dynamic factors

- **Climatic conditions – precipitation**

Solutions. It can be concluded that, in order to insure the area's stability and the environment's protection, we appealed to the following three solution categories: Depending on the land's slopes, the flanks surface will be designed through debridement at values of 9-11^0; Ditches and ear drains will be designed and made to collect the ooze waters and their gravitation evacuation towards the established area; Making of some draining off systems that intercept the phreatic water blanket and which decrease the water's level at the imposed depths by making a lever drains' line, located upstream and having lengths of over 100 m (130 m), lock chambers and an evacuation network with a ditch which has an end sewage outfall and of discharge towards its emissary.

Figure 6.1 Control panel

Figure6.2 Visit chamber lever drain with sensor

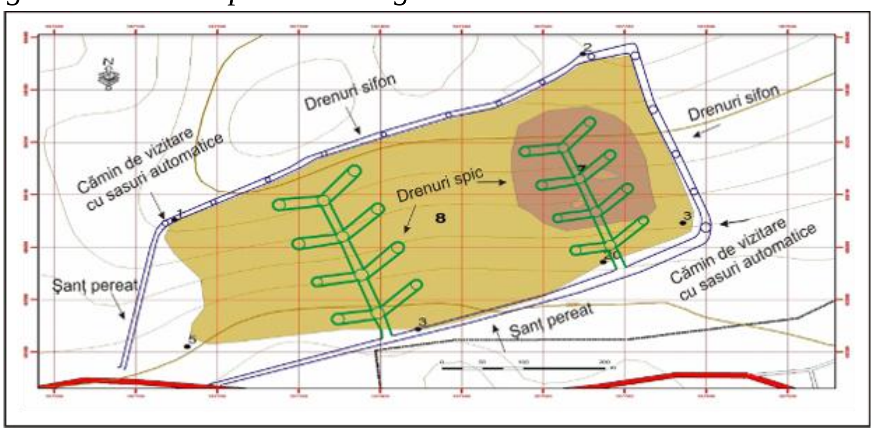


Figure 6.3 Section through a lever drain network

6.4. Prevention, diminishing and refutal of hydrological hazards

Defence structural measures against floods (according to Stănescu 2002)

Structural prevention measures are technical measures advanced by engineers. According to the way in which these works act against high floods, the structural measures are split into many categories (Selarescu M., Podani M., 1993):

a. Measures that reduce the high floods' top discharges.

b. Measures that reduce the maximum levels in channels, respectively the rivers' channels cleaning;

c. Lessening the high floods duration by drainage works.

d. Defending the endangered population and the objectives by dams and defence walls.

Figure 6.4 Planned channels

Defence unstructural measures against floods

We mention:

1. Major channels and grazing lands' zonation;
2. Forecast quality improvement;
3. The correlated exploitation of deposits and of other hydrotechnical works;
4. The agricultural land's usage planning in a correct manner in order to hold water in the soil.
5. Institutional reform.

When applying these unstructural measures, a public consultation, based on surveys or even interrogations and direct relations, presents a crucial importance. Some aspects related to these measures are presented below (cf. Giurma, I., 2003).

a. Minor channel's zonation and management

b. Discouraging the floodable areas' development

c. High floods hydrological warnings and forecasts

In the same time, „warnings" and „hydrological forecasts" are elaborated which are disseminated in the territory, depending on the situations from the field.

The warnings elaboration, validation and broadcasting are made based on collected data from the field.

The hydrological warning is issued based on meteorological forecasts:

- when the possibility to exceed the defence quotas is foreseen;
- when other dangerous hydrological phenomena are likely to occur (important discharges from the flanks, torrents, non-permanent valley, fleets);

The hydrological alert is based on meteorological forecasts and rivers state:

- when the possibility to exceed the defence quotas is foreseen;
- when other dangerous hydrological phenomena are likely to occur (important discharges from the flanks, torrents, non-permanent valley, fleets);

6.5. Case study – Flooding of areas located upstream from Firiza Accumulation Lake in case of accident at Strâmtori dam

To update this case study, firstly a ***complex hydrological study concerning the water discharges in a designed regime (accumulation lake) Firiza on the Firiza and Săsar rivers*** is carried out. Afterwards the **dislocation scenarios and hypotheses *are*** elaborated.

Therefore, according to the study carried out by „Traian Vuia" Polytechnic Institute, the Construction Faculty, School of hydrotechnical construction and territorial improvements, Timişoara

1988 and of a rich literature concerning the dislocation scenarios of some dams, the hypotheses for the dislocation hydrograph's calculus were underlined. At these, ***the dislocation hydrographs' calculus*** is added, as well as ***the high floods ripples' conveyance in the accounted hypotheses.***

To establish the high floods ripple's conveyance conditions for dislocation, the UNDA 85 program was carried out for the mentioned dislocation hypotheses.

- ***hypothesis I*** – Strâmtori dam's ***maximum damage*** by the dislocation of 6 blocks
- ***hypothesis II*** – ***average damage*** through the regulating gates and their riflers' dislocation
- ***hypothesis III – for the*** natural high flood's ***hydrograph*** with a 0, 1% probability (for verification)

From the results' analysis, more damage hypothesis come up. In this respect, ***objectives affected by floods in case of Strâmtori dam's maximum damage*** were established.

In case of Strâmtori dam's maximum damage, Baia Mare municipality's most important areas are flooded – in Ferneziu district.

Numeric model with the flooded surface

Based on the data obtained by Timişoara Polytechnic Institute, we tried to update, according to new software and modern techniques, the 3D model overlapped on the ortophotoplan of the affected areas in case of accident. To accomplish this, the following phases were followed:

- creating the land's numeric model through the contour curve with their value (in cm)'
- marking the hydrographical network to establish the thalweg's line;
- the limit to know where to stop the values' interpolation.

The model we got represents a surface (bitmap) made of cells with the leg of 5 meters (real value). Each cell wears an altitude value; based on it, the water's layer surface resulted after the dam's break down is still calculated. The water's layer depth is represented in (Figure 6.5). There are some irregularities resulted from the interpolation's imperfection and especially from the numeric model's inaccuracy. A better defined one is necessary.

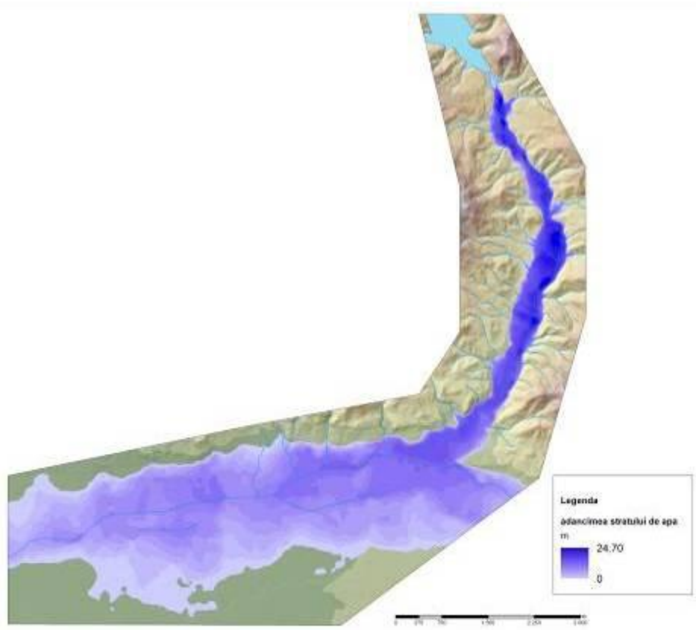


Figure 6.5 Water layer's thickness

6.6 Prevention, diminishing and refutal of climatic hazards

The modifications' detailed knowledge which the city imposes to the climatic elements within its own structure requires the performance of instrumental micro and topo – climatic observations on a long time period simultaneous in the city's midland and its surrounding area and in different climatic conditions.

CHAPTER 7

CONCLUSIONS

Through the identification and analysis of geomorphic, climatic and hydrological hazards from Baia Mare municipality, we underlined the areas that can be affected by one or more of these factors.

The risk maps according to the calculus algorithm classified the natural and anthropic risk possibilities in areas with maximum occurrence probability, with average potential, with low potential and area without a risk potential.

Each area customizes through characteristic elements, restrictions, usage proposals and constructive recommendations.

In what concerns the structures vulnerability that can be affected by a certain type of risk, these can be multiple: public, industrial and agricultural buildings, water feeding and sewage networks, transport infrastructure, airlines networks, gas transport pipelines, electrical cables, optical fibre, etc.

All these elements behave differently, depending on the risk type by which they are affected. This means that their vulnerability to the destructive characteristics is different.

The exceeding probabilities' curve for the destructive characteristics will be determined based on a tridimensional analysis of effort – kinematic cripplings or analysis, using specific mathematical models.

After mentioning the analysis' need and advantages based on risk evaluation, in comparison with those based on security coefficients and important categories, the question comes to establishing an **accepted hazard** that becomes a criterion in order to chose and measure the constructive solutions for prevention or remedy.

Choosing the hazard's accepted level, must lead to general economic advantages, as well as to a lower mortality rate than the natural one.

Mentioning the accepted hazard is a complicated thing. Through the consequences' complexity, to mention an acceptable hazard level automatically has social, economic, political implications related to the environment's protection, etc, and for this reason it is a decision that must be taken by the society, even more when the public opinion perceives the risk differently due to different hazard phenomena.

Consequently, the accepted hazard presents a decision based on some probability and some consequences for a certain risk's acceptance.

The existence of damages, human life loses, leads to the conclusion that the financial or technical-economic criteria are not relevant, taking into account the fact that an economic analysis is impossible, because it is accepted the idea that it is impossible to attribute monetary value to human life.

A highly important aspect related to the accepted hazard level is the trust given by the community to the professionals' opinion, knowing the fact that loss of trust is the most frequent explanation in the conflicts between experts and population. In this respect, the increase of trust depends on the risk to which it is exposed.

We think that an emergency measure is to create a monitoring network of the identified areas with hazard, in conformity with the effective republican regulations and norms.

We warn that the types of hazards and the affected areas are a spatial and temporary sequence, these being able to rapidly develop and in an exceptionally way, decrease.

This documentation, which, besides the last minute methodology used in this field, is based also on a long experience (over 40 years) of observations, studies and projects carried out in Baia Mare municipality's area, can gain new valences through the investigations' thoroughness and through the calculus algorithms improvement.

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