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FACULTY OF ENVIRONMENTAL SCIENCES

NATURAL AND TECHNOLOGIC RISKS IN THE ARIEŞ RIVER MIDDLE BASIN. VULNERABILITY REDUCTION OF THE LOCAL COMMUNITIES

- summary -

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Key words: risk, vulnerability, vulnerability reduction, disaster prevention, population preparedness

INTRODUCTION

When speaking about geology, and especially when it is defined as a science, it must be taken into account the Earth System, in which geology as a science and processes is incorporated, and therefore, inseparable. In fact, the Earth System, as the collocation also demonstrates, is a well structured and integrated whole, having four basic components: the atmosphere, the hydrosphere, the biosphere and the lithosphere, which are in an continuously interaction, acting in a systematic and variable manner, each modifying in more or less determined proportion the surface of the system, meaning the Earth System.

This paper is centered on the natural and technologic risks and their prevention and is aiming to find, within the limits of the current resources, in a realistic and objective manner, a few solutions for reducing the local communities' vulnerability.

The major objectives this paper focuses on are the identification and assessment of natural and technologic risks, from the point of view of their impact on the populations, the assessment of social vulnerability and finding solutions for its reduction, which will allow a future development of the area.

Therefore, the scientific and research activities were structure in a synthesis comprising eight chapters, following the data collecting and analysis. Thus, the final paper will include the succession of the research phases, within chapters:

- Introducing the notions and concepts regarding risks, emphasizing those elements which will be used within the paper: concepts definitions, risks classification, risks assessment, risks perception and communication;
- Documenting the term “vulnerability”: identification of vulnerable groups, influencing factors (geographical, social, economic and political), assessment and reduction methods;
- Describing those physical – geographical elements characteristic to the studied region, from the point of view of their influence on risks and disaster occurrence;
- Identifying and assessment of natural hazards which affect the communities in the Arieş river middle basin (hazard assessment, communities vulnerability assessment to floods, landslide susceptibility map elaboration);
- Identifying and assessment of technologic risks which affect the local communities in the Arieş river middle basin (matrix risk assessment for each mining activity, surface water pollution assessment, case study - accidental pollution);
- Estimating the population's social vulnerability, from the perspective of its ability to cope with or to recovery after an emergency situation;
- Finding of suitable vulnerability reduction methods to the hazards the local communities are exposed to, taking into account the regions specificity and development potential;
- Synthetic presentation of hazards, risks and vulnerabilities, the results being represented graphically, on a composite map.

From the scientific point of view, the research this paper is based on, is integrated and interdisciplinary, using methods and concepts from natural and sociologic sciences. To tackle the entire range of environment and men relations and the vulnerability assessment, data and methods from other sciences were used: environmental engineering, geography, geomorphology, sociology, psycho – sociology etc., and statistical data. Data and methods from other sciences, except geology and environmental sciences were use, to tackle the thesis' theme in all its complexity.

The photos and maps used in this paper are created by the author, excepting those mentioned in the text.

CHAPTER 1
THEORETICAL CONCEPTS REGARDING RISKS

1.1. "Risk" definitions

Defining natural and technologic risks represents the first step in the elaboration of impact studies, land-use planning, emergency response plans, contributing to the human society's sustainable development.

The newest definitions is given by the International Strategy for Disaster Reduction - ISDR, in 2009: „a potentially damaging physical event, phenomenon or human activity that may cause the loss of life or injury, property damage, social and economic disruption or environmental degradation".

Hazard is characterized by a geographic localization, intensity (magnitude), frequency and occurrence probability. The manifestation and the causes are well known, the moment and place of occurrence are random (Mac, 2003).

Tightly connected to hazard is the risk. Many times, these two terms are confused. Hazard is a natural or anthropic process, characterized by its potential to produce damages, in other words, the general source of a future danger. The risk represents the human society or its valuable goods or the environment exposure to a hazard and is calculated through the product between probability and damages (Smith, Petley, 2009).

To conclude, a hazard represents the potential threat of an event, and not the event itself. It becomes a risk if it affects to some extent a human community.

The Contemporary Romanian Language Dictionary in 1980 defines risk as a "potential danger, the probability to suffer a failure, a loss". The same definition can be found in the Encyclopedic Dictionary from 1999.

In 2004, the United Nations Development Programme – UNDP offers another definition: "the probability of harmful consequences, or expected losses (deaths, injuries, property, livelihoods, economic activity disrupted or environment damaged) resulting from interactions between natural or human-induced hazards and vulnerable conditions. Conventionally risk is expressed by the notation Risk = Hazards x Vulnerability. Some disciplines also include the concept of exposure to refer particularly to the physical aspects of vulnerability.

The classic risk definition, as the product of an event occurrence probability and the negative consequences it may have, expressed by:

$$\mathbf{R = P \times C}$$

(Where R – risk, P – probability of occurrence, C - consequences) associates two distinct elements: hazard and receptor (most of the time, the population).

Many times, the following relation is used:

$$\mathbf{R = hazard \times vulnerability}$$

expressing the connection between an event and its consequences. Within a region, the risk is relatively constant. But the community's vulnerability is different: reaction to danger, preparedness level etc. According to this relation, risk can be connected to the high frequency hazard and low vulnerability, or to a low frequency hazard and high vulnerability. The phenomenon evolution has three stages: the hazard stage, in which there is only the hazard, risk stage, in which the hazard affects human society and finally, the disaster occurrence (Alexander, 1993).

To human society, there are two kinds of risks: an acceptable one, in which the damages and losses are tolerable for the population and the disaster, in which the damages can not be supported by the local community. The disaster is a result of the interaction between hazard and vulnerability and it represents the insufficient preparedness level to emergency situations. Risk mitigation includes several regulation, strategies and vulnerability reduction measures, aimed to a continuous development of the human society.

It must be mentioned that regardless of the implemented reduction measures, there is no where on Earth and in no situation an absolute safety state, for the human society and its products. There will always be a so called "residual risk" (Ozunu, Anghel, 2007).

1.2. Qualitative risk assessment

Qualitative risk assessment represents the first step in hazard and risk assessment studies. Depending on the nature and gravity of possible consequences, it is decided whether a further, more detailed risk analysis is required, that is quantitative assessment. These qualitative assessments can be applied starting with the design phase, to reduce the possible identified risk and consequences.

In risk assessment, several factors are used, characterized by certain gravity levels: probability, consequences, uncertainty, existing warning systems, public pressure, hazard assessment and finally, risk assessment (Lee, 1999).

CHAPTER 2
VULNERABILITY

2.1. Definitions

Vulnerability is a term used by different groups, which give it different meanings: academic field, disaster management societies, climate changes organizations, development agencies. These different meanings come from the different needs these groups have.

In 2004, Wisner proposed a comprehensive definition: „the characteristics of a person or group and their situation that influence their capacity to anticipate, cope with, resist and recover from the impact of a natural hazard (an extreme natural event or process). It involves a combination of factors that determine the degree to which someone's life, livelihood, property and other assets are put at risk by a discrete and identifiable event (or series or ´cascade´ of such events) in nature and in society" (Wisner et. al, 2004). An essential aspect of this definition is the inclusion of the scale at which the vulnerability is measured: vulnerability is different at the household level then at national level, so the reduction measures must be elaborated and applied differently.

The International Strategy for Disaster Reduction – ISDR proposed a simple definition: "the conditions determined by physical, social, economic, and environmental factors or processes, which increase the susceptibility of a community to the impact of hazards" (ISRD, 2009).

The different vulnerability definitions are reflected in several concepts and models, which aim at its systematization and assessment: the double structure of vulnerability – Bohle, 2001, Pressure and Release model PAR – Blaikie, 1994, BBC model – Bogardi et al. 2004, components model – Villagran, 2001.

2.2. Vulnerability characteristics

Within the population – environment system, vulnerability is the result of the complex interactions between socio-politic and psychical processes, operating at different temporal and spatial levels. This principle is based on the different between the major vulnerability components (exposure, sensitivity and resilience), the factors which influence each dimension and the connections between them (Thomalla et. al, 2006) (Fig. 1).

Vulnerability is a dynamic, intrinsic characteristic of a community. Vulnerability refers to the future (Birkmann, 2006). Vulnerability characterizes the community permanently, regardless if a negative events occurs or no. However, it is expressed only during an event, the level at which it can be observed depending on the event's magnitude.

Vulnerability changes continuously. For example, it can be modified by another disaster: if a community becomes poorer and lacks financial and human resources after a disaster, the following emergency situation can have more severe consequences. Vulnerability characteristics change depending on the geographic scale. The parameters which determine vulnerability are different at household, community or state level (Birkmann, 2006).

2.3. Factors influencing vulnerability

Poverty influences vulnerability, as it reduces individuals' ability to respond and to cope with environmental changes.

Health is the basis of work productivity, learning and intellectual, emotional and physical development capacity. Regarding vulnerability, a poor health status reduces the population's capacity to adapt to any changes, including the environmental ones (UNEP, 2007).

Globalization had as results an increase of the economic and financial flows at international level, which in fact creates a high interdependence between states, despite the differences between them. The new governance systems turned into an increase of intervention capabilities at national level, which lead to a vulnerability reduction.

The new developments in science and technology support vulnerability reduction, at different levels and in different ways.

Demographical factors, like gender, race, family structure, migration, life style, mortality, morbidity and fertility influences vulnerability (Wisner et. al, 2004). The young and elder are more vulnerable to natural hazard impacts. The elder are less mobile (their evacuation is more difficult), are less illness resistant and have access to few resources.

Another vulnerable group is women. They remain disadvantaged, despite the improvements brought to the education and information access, labor market etc. (Wisner et. al, 2004).

2.4. Vulnerability assessment methods

Vulnerability is measured by comparing hazard magnitude to society's and individual's vulnerability level.

Vulnerability assessment represent the systematization and evaluation in the context of a household, group of people, region or state, a sector or a system, connected to different types of hazards. After its systematization and assessment, there can be elaborated and implemented regulations, procedures, measures and programmes aimed at vulnerability reduction (Villagran, 2006).

Compared to the large number of definitions, there are few assessment methods.

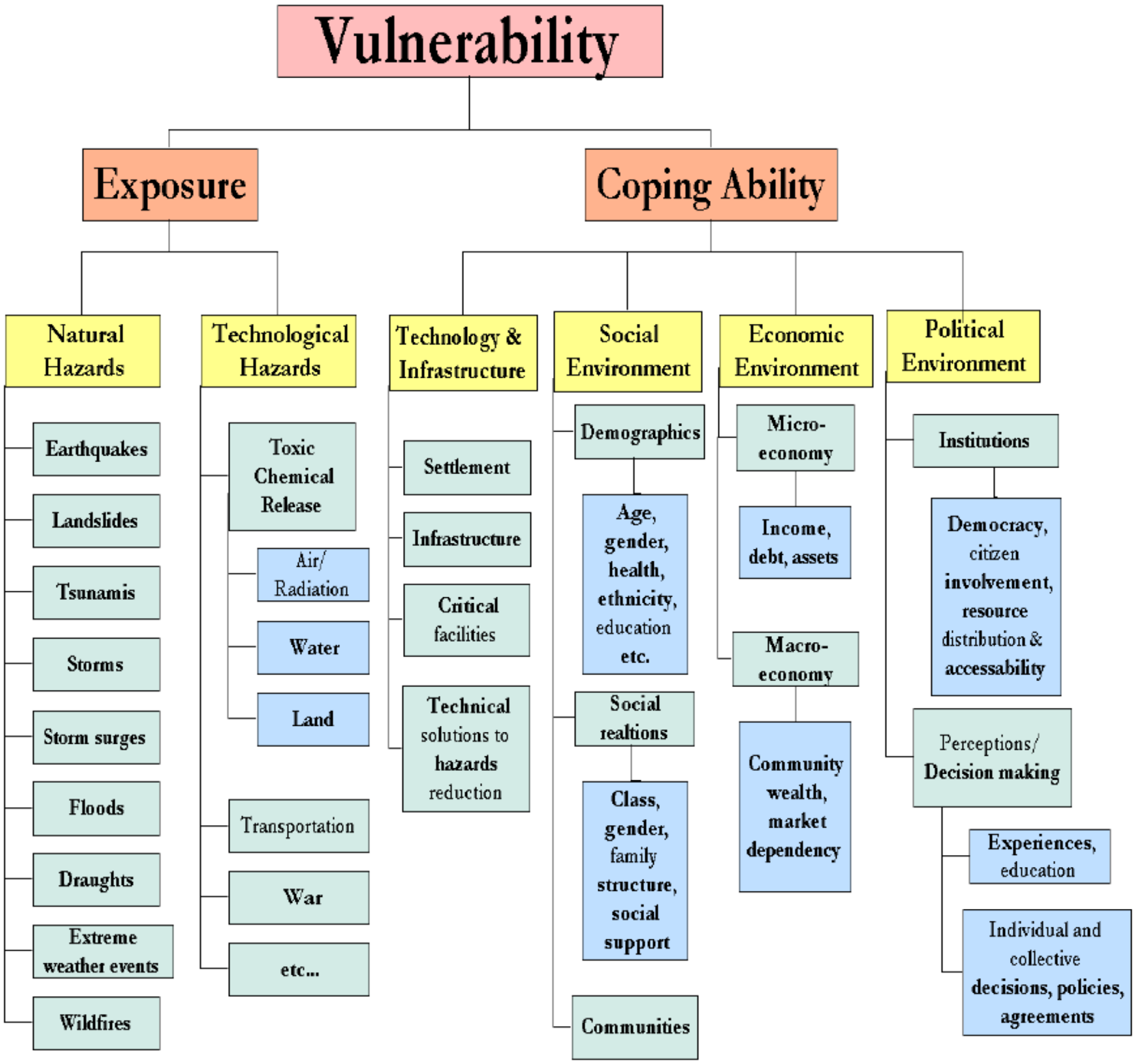


Fig. 1. Vulnerability, depending on exposure and coping capacity
(http://hero.geog.psu.edu/products/protocol.pdf)

CHAPTER 3
STUDY AREA DESCRIPTION

3.1. Position and limits

The studied are is the Arieş river middle basin. The middle basin has a total surface of 1.406 km^2, which represents almost half (46%) from the total river basin surface (2.950 km^2).

The limits are given by the heights of land between several water courses, as it involves a river basin. Along the Arieş water course, the upper limit was considered the Câmpeni town (Fig. 2).

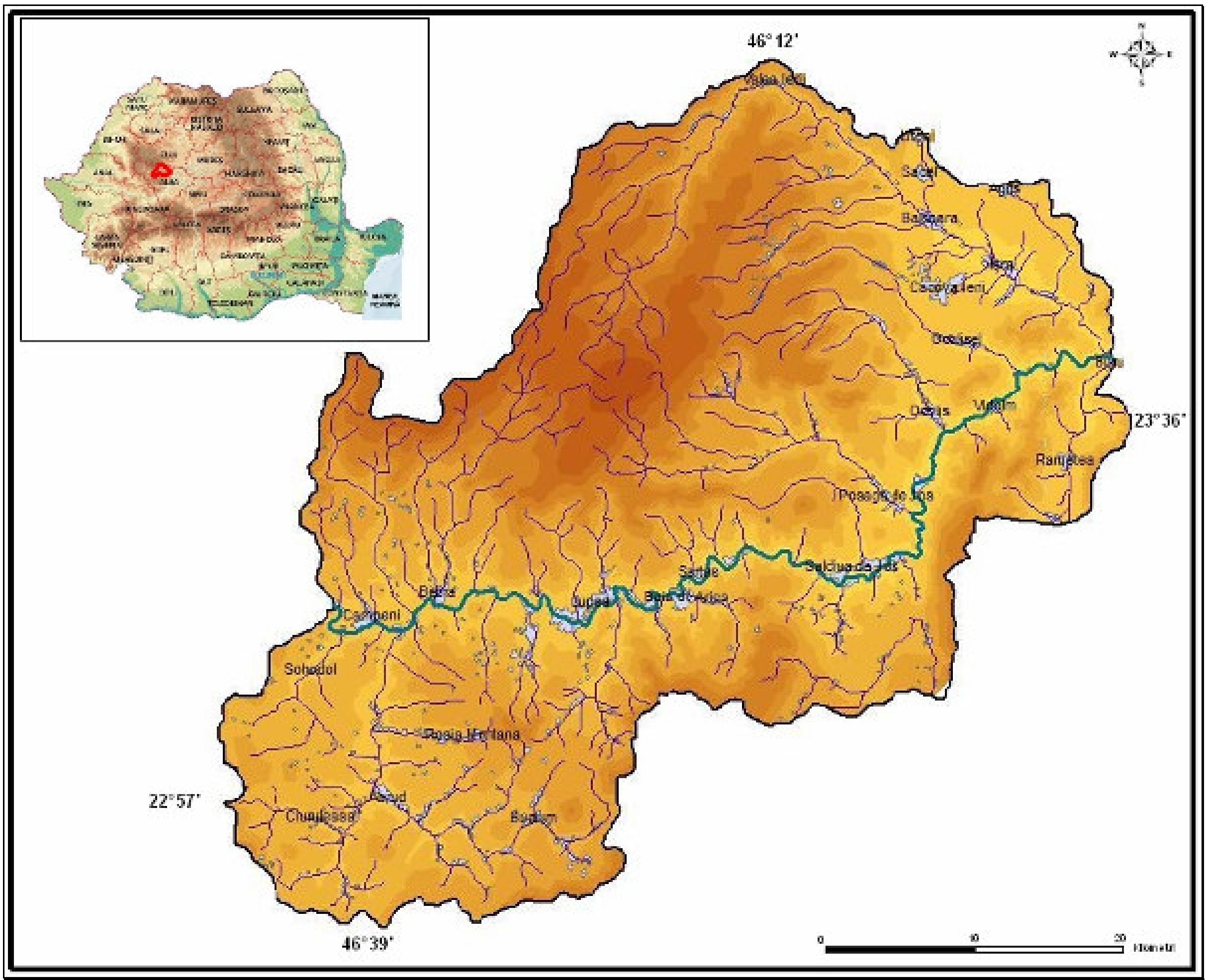


Fig. 2. Geographical position and limits

The Northern limit separates the Arieş river middle basin by the Someşul Mic river basin. Along the Arieş river course, the lower limit is Buru village. The Eastern limit was set based on the inclusion of these water courses in the region within the Transylvanian Carpathians hydric regime (Ujvari, 1972). The Southern limit follows the heights of 1.000 and 1.200 m, which separates the Arieş tributaries by the Mureş tributaries.

3.2. Geology of the study area

The geologic structure of the Arieş river middle basin is characterized by a large variety of geologic formation. There can be observed sedimentary formations (conglomerates, sandstones, clays, and limestone), sedimentary – volcanic formations (tuffs, volcanic conglomerates etc.), magmatic and volcanic rocks with different chemistry, from acid to basic, as well as metamorphic formations (with different levels of metamorphism).

The metamorphic formations in the Apuseni Mountains have a complex tectonic structure and a varied lithology. In the studied area there are mesometamorphic crystalline schist (Someş and Baia de Arieş crystalline), epimetamorphic crystalline schist (Arada, Biharia and Muncel crystalline), and hercynian crystalline schist (Păiuşeni, Arieşeni, and Vulturese – Belioara crystalline) (Mutihac, 1990).

The sedimentary formations vary as lithology and age. They form the coating of the crystalline rocks or the filling of the post/tectonic basins. Depending on the stratigraphic differences, the sedimentary formations can be classified in three domains: Bihor autochthonous, Codru nappe system and Biharia nappe system.

The Neocene magmatism was generated in an extensive geotectonic context (Balintoni, Vlad, 1996). Its products can be found on several alignments, oriented NV – SE, being represented through basaltic andesites, andesite, quartz andesite, dacite and rhyolite. In the studied region, it is represented by the eruptive bodies from Baia de Arieş, Roşia Montană – Roşia Poieni and Bucium, and consists of dacites, andesites and basaltic andesites. The magmatic products (volcanic and sub volcanic) are accompanied by polymetallic mineralization of Au, Ag and Cu (Fig. 3).

The metal genesis connected to the Neocene volcanism is very important and it resulted in more varied and richer valuable mineral substances concentration. There must be mentioned the gold-silver deposits in the Arieş-Caraciu-Săcărâmb-Zlatna area, also known as the golden quadrilateral (Mutihac, 1982).

Polymetallic sulphur deposits, like those in Baia de Arieş, formed in the same volcanic period. Many accumulations have a mixed character, gold and polymetallic, due to the ore composition, like Baia de Arieş – Afiniş (gold, silver + lead, zinc, copper) or Baia de Arieş – Ambru (lead, zinc + copper + gold, silver) (Vlad, 2005.

Copper deposits, in which predominates chalcopyrite and rarely silver, are known in the Bucium region and around Deva. It must be mentioned the Roşia Poieni deposit, having significant quantities (617 mil. t).

The banatitic metal genesis is responsible for the formation of some mineralization found in the Apuseni Mountains. It has generated, first of all, the iron pyrometasomatic accumulations, like Masca – Băişoara and Cacova – Băişoara.

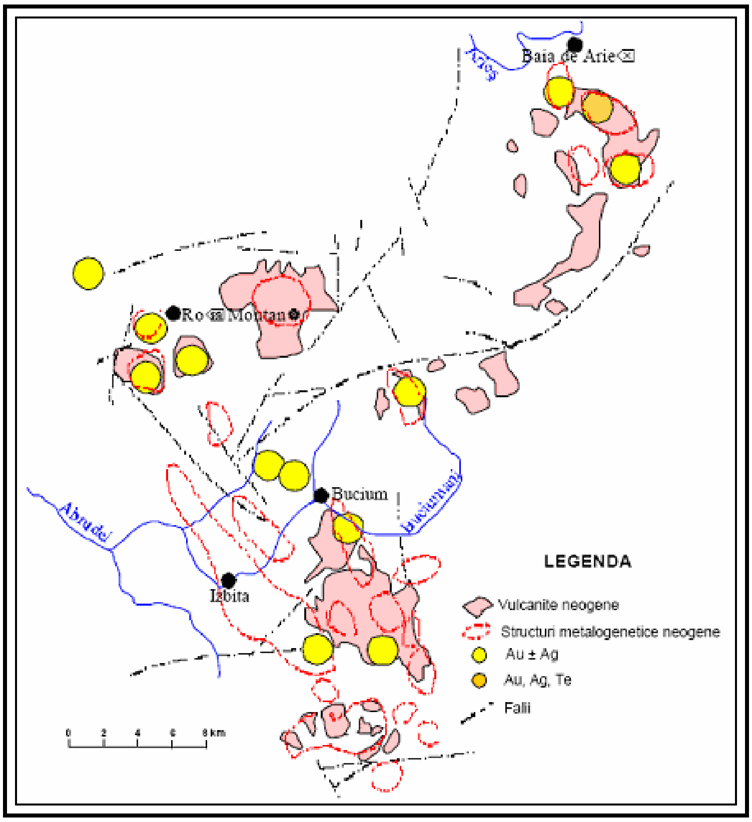


Fig. 3. The Roşia Montană – Bucium – Baia de Arieş metallogenetic district (Map of mineral resources, 1983, cited by Luduşan, 2005)

3.3. Relief

The present relief of the studied area suffered major changes, imposed by its long time evolution, changes produced by the glacier erosion and by the recent, normal erosion, based on the existence of an old hydrographic network.

From the morphologic point of view, the Arieş river middle basin can be divided in three areas:

- The mountain area – includes the mountains which limits the Arieş valley and are 400 - 1.600 m tall (1.826 m in Muntele Mare);
- Sub mountain area – includes the large floodplains, coming down to the Arieş valley;
- Sedimentary formations area, which is divided in:

- Alluvial cone – accumulations of sedimentary deposits, with different stratification, deposited in the lower water courses, at the confluence with major rivers (especially with the Arieş river);
- Floodplain areas – along rivers (characteristics is the left side Arieş flood plain);
- Delluvial deposits areas – represents the connection of the hills with the lower surfaces (floodplains, terraces).

The Arieş river middle basin is characterized by altitudes between 400 and 1.800 m. The lowest altitude is situated at the level of the Arieş major river bed, in Buru village (357 m), and the highest is situated in Muntele Mare (1.826 m). Watching the area's physical map, it can be seen that the surfaces between 400 and 600 m are predominant (Fig. 4).

The Arieş River flows across the Apuseni Mountains, dividing them almost in half. The Arieş valley, its middle sector, includes several Apuseni Mountains segments: Muntele Mare, Metaliferi Mountains and Trascău Mountains.

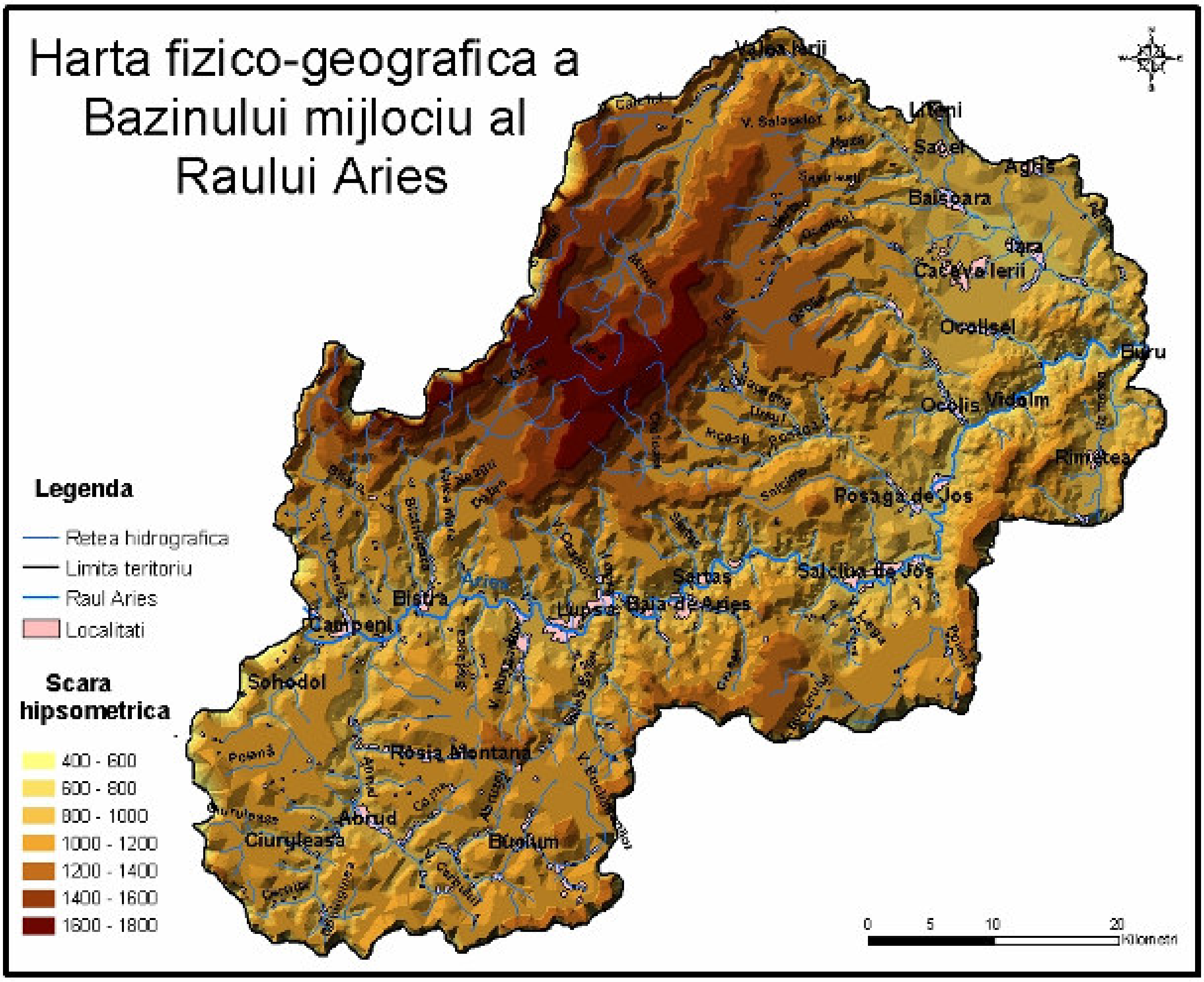


Fig. 4. Hypsometric map of the Arieş middle river basin

Along its course, the Arieş River and its tributaries flow across several depressions, most of them small ones, situated in the mountain area. These depressions were platforms which facilitated the development of human settlements. In the Arieş River middle basin, upstream to downstream, there can be found: Câmpeni Depression, Abrud Depression, Bistra Depression, Lupşa Depression

(Fig. 5), Sălciua Depression (Fig. 6), Ponor Depression, Poşaga Depression, Ocoliş Depression, Trascău Depression, and Iara Depression.


Fig. 5. Lupşa Depression **Fig. 6. Arieş River in Sălciua Depression**

3.4. Climate

The climate of the studied region is influenced by the general atmospheric circulation and by the varied structure of the active surface. Within the Arieş river middle basin, there are regional and altitudinal differences. In the studied area, the climate is moderate continental. Due to the fact that the Arieş River is situated on the Eastern part of the Carpathians and the decrease of altitude from upstream to downstream, the climate discontinuities are evident. In the interest area, there are Southern and South – Western influences, which are responsible for the warm air flows, of tropical origins. There are also Northern and North – Eastern influences, which bring cold air flows, of polar and arctic origins.

3.5. Hydrography

The hydrographic network comprises many water courses, thus having a high density. Most rivers are included in the short and very short rivers category, the Arieş River being the only exception, because it is included in the middle rivers category, due to its length, of 167 km (Fig. 7).

The Arieş River flows hrough the Apuseni Mountains. Downstream Câmpeni, after the confluence of Arieşul Mare and Arieşul Mic, the Arieş River has a length of 122 km. In the middle river basin, its length is 68 km.

Downstream Câmpeni, the Arieş river has as tributaries rapid water rivers from the Muntele Mare: Bistra (16 km in length, 44 km^2 basin area), Bistrişoara, Valea Mare (19 km in length, 70 km^2 basin area), Dobra, Valea Caselor, Lupşa, Sălciuța, Poşaga (22 km in length, 112 km^2 area), Ocoliş (14 km in length, 67 km^2 basin area), Ocolişel (23 km in length, 67 km^2 basin area), Valea Dolii, Sohodol, Abrud and Roşia Montană, Muşcanilor Valley, Şesei Valley, Cioara, Largă Valley and Remetea (Ujvari, 1972).

The high number of left tributaries, after the confluence with Abrud River, offers the entire middle river basin an asymmetric character, with an evident development on the left.

The Arieş river flow regime is constant, with periods of high waters in spring and summer and low waters in autumn and winter. From this point of view, it can be said that the Arieş river basin is fitted perfectly in the climate characteristics specific to the altitudes between 400 and 1.400 m.

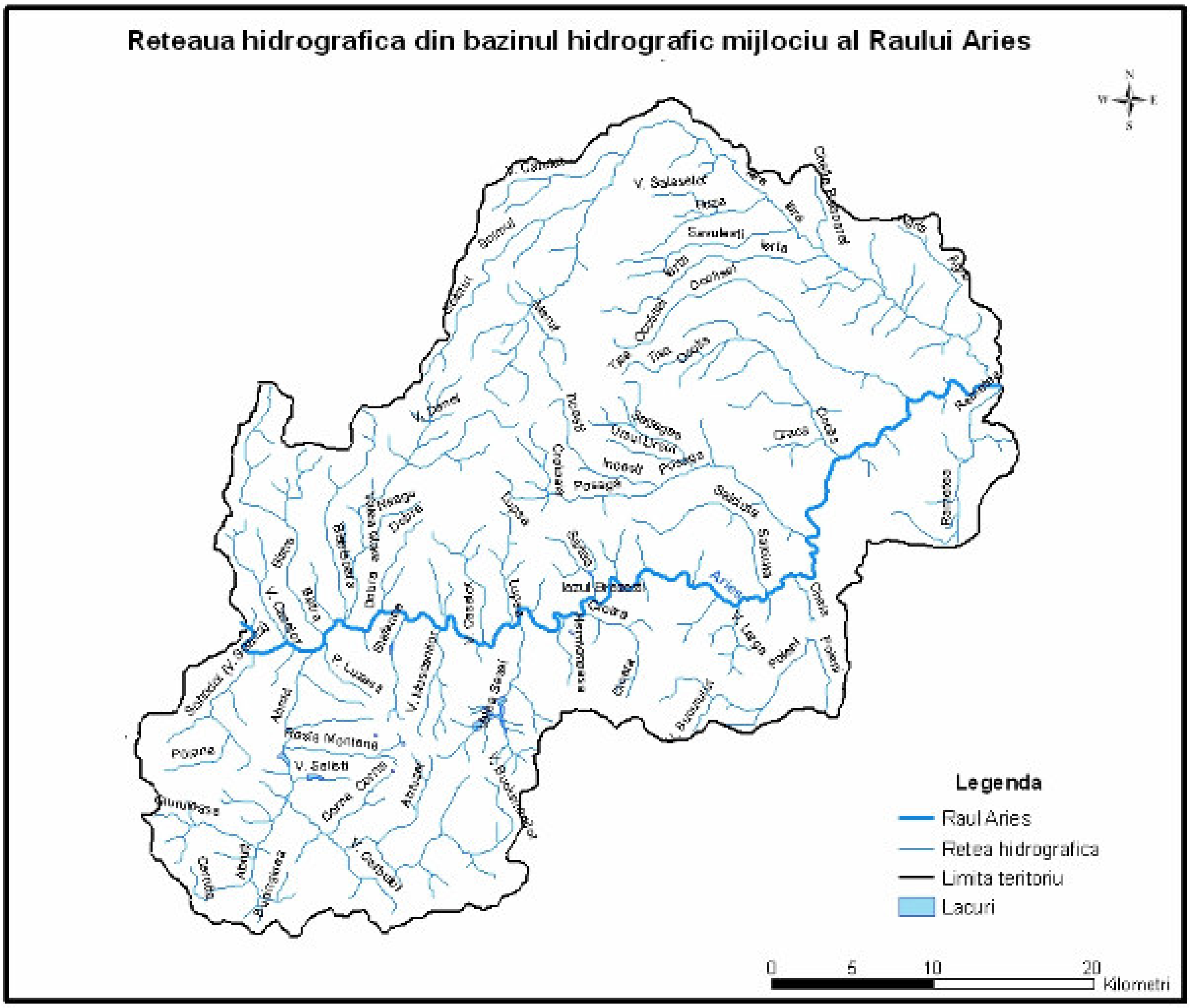


Fig. 7. The hydrographic network in the Arieş river middle basin

3.6. Flora and fauna

The medium altitudes within the Arieş river middle basin allowed the growth of herbaceous associations and also wooden associations. In the first category, there are: rocky meadows, in the Bedeleu Mountain, detritus meadows on Runc Valley, Ascunsă Valley and Scăriţa-Belioara natural park, short sub alpine and mountain meadows and scrubs, in Runc Valley and Scăriţa-Belioara natural park, calciphilum meadows, situated in Scăriţa-Belioara, Runc Gorges, Bedeleu Mountain, Poşegii Gorges, Segacea Valley, Piatra Vidolmului, Ascunsă Valley, associations specific to rocky soils in mountain regions, in Runc Gorges, Poşegii Gorges, Colţii Vulturesei, Piatra Urdaşului, Runc Valley, Bedeleu Mountain, Scăriţa-Belioara, Huda lui Papară, hygrophilous flood plain meadows, identified on many valleys in the middle river basin, eutrophic swamps in Runc Gorges, Huda lui Papară Cave and along the Runc Valley (Crişan et. al, 2004).

3.7. Soils

The studied region is characterized by a large variety of soil types, diversity determined by the spatial and temporary variety of natural pedogenetic factors. The soil types' distribution in the Arieş river middle basin is influenced by the relief forms, geologic structure, climate conditions and vegetation, overlapped by local influences. Therefore, in the studied region there are: eutricambosoil, districambosoil, prepodsoil, preluvosoil, luvosoil, andisoil, rendzina, erodisoil.

3.8. Natural parks

The Arieş middle river basin is characterized by a natural varied landscape, whose protection is implemented through protected areas concept. According to Law no. 5/2000 regarding the approval of the National Landscaping Plan – Section III – protected areas, the protected areas are those natural or built geographic and/or topographic limited regions, which include natural and/or cultural valuable goods and are such declared, to reach the objectives of patrimony values preservation.

In the studied area, the below natural parks and nature monuments were identified, according to Law no. 5 /2000.

Tabel.1. The list of natural parks and nature monuments, according to Law no. 5/2000:

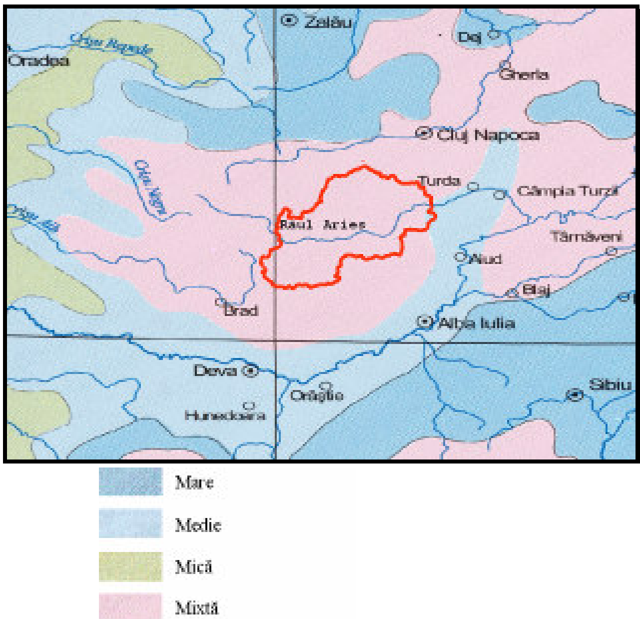
No.	Name	Localization	Type	Area (ha)
1.	Piatra Despicată	Roşia Montană Commune	geologic	0,20
2.	Huda lui Papară PN-F	Sălciua Commune, Sub Piatră village	speleological	4,50
3.	Pădurea Vidolm	Ocoliş Commune, Vidolm village	wooden	44,20
4.	Molhaşurile Căpăţânei	Bistra Commune	botanical	5,00
5.	Şesul Craiului-Scăriţa Belioara	Poşaga Commune, Poşaga de Sus village	complex	47,70
6.	Cheile Poşegii	Poşaga Commune, Poşaga de Sus village	complex	10,00
8.	Cheile Runcului	Ocoliş Commune, Runc village	complex	20,00
9.	Cheile Pociovaliştei	Ocoliş Commune, Runc village	complex	25,0
11.	Peşterile Lucia	Sohodol Commune	speleological	1,00
12.	Peştera de la Groşi	Sălciua Commune, Sub Piatră village	speleological	1,00
14.	Detunata Goală	Bucium Commune	geologic	24,00
15.	Detunata Flocoasă	Bucium Commune	geologic	5,00
16.	Poiana cu narcise de la Negrileasa	Bucium Commune	botanical	5,00
17.	Piatra Corbului	Roşia Montană Commune	geologic	5,00

CHAPTER 4
IDENTIFICATION AND ASSESSMENT OF NATURAL HAZARDS

For the study of the natural hazards within the Arieş river middle basin, the most significant ones were chosen which occur in this area and which affect the local communities.

4.1. Climatic hazards

White frost – the area is situated in a mountain region, therefore being characterized by a mixed vulnerability (low, middle, high), depending on the altitude, relief form and slope exposure to cold air advections (Bogdan, Marinică, 2007) (Fig. 8).



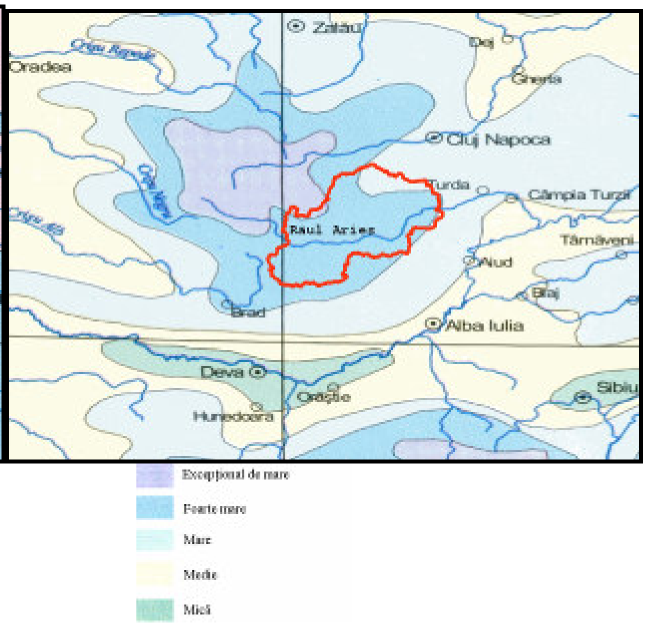


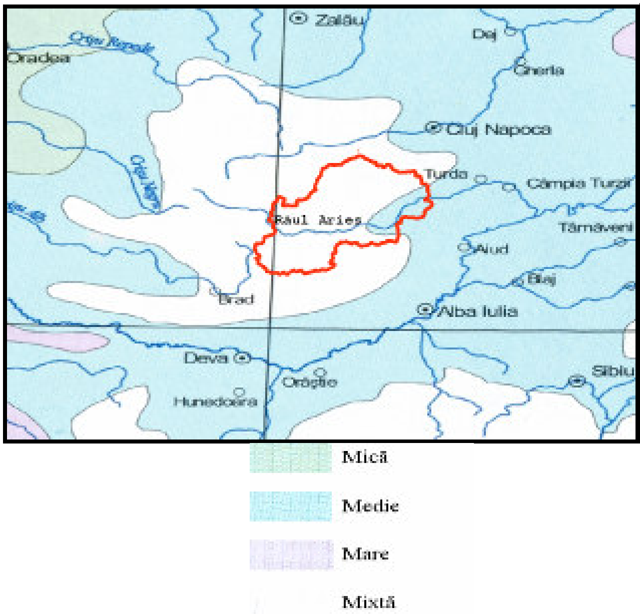
Fig. 8. Vulnerability to frost and white frost (according to Geographical Atlas, 2002) **Fig. 9. Vulnerability to rime**

Rime – depending on the average and maximum annual rime days, the studied region was included in the high and very high vulnerability territories (Fig. 9). This fact can be explained by the climatic conditions specific to mountain regions: wet air, low temperatures and high wind speeds.

Glazed frost – in mountain regions, including the Apuseni Mountains, the mean multi annual glazed frost days is low: 0.5 – 1 day/year (Câmpeni- 1.1 days/year, Băişoara- 0.3 days/year) (RMGC, 2006). National and county roads affected by glazed frost are situated near Abrud, Ciuruleasa, Câmpeni, Baia de Arieş, Sălciua, Roşia Montană and Rimetea. As a result, the vulnerability is moderate.

Fog – persistent fog makes road traffic difficult, affecting especially the roads along the valleys and rivers. Based on the mean annual fog days and on the topoclimatic characteristics, the area is situated in the very high vulnerability region.

Hail – the vulnerability to hail is conditioned by the mean and maximum annual hail occurrences and by the precipitations intensity during the warm season.



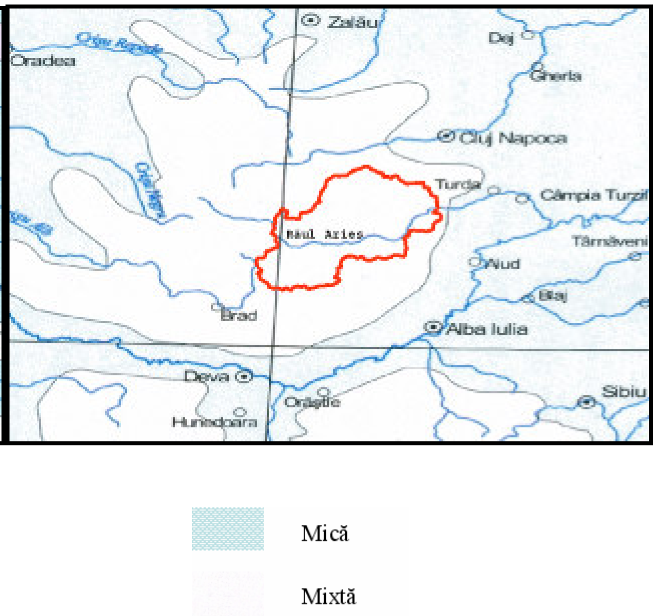


Fig. 10. Vulnerability to hail (according to Geographical Atlas, 2002)

Fig. 11. Vulnerability to snowstorms

The regions situated behind the barriers formed by the Carpathians are characterized by a moderate climate. In these regions, hail is a rare phenomenon: the average annual hail days is 2 – 4 days/year. Due to the fact that the studied area is a mountain one, the hail vulnerability is highly influenced by the slopes exposure to wet air advection or to Sun (Fig. 10).

Snowstorms – the barriers formed by the Carpathians protects the inner areas, limiting the snowstorm occurrence areas in South and East Romania. Thus, in the area situated behind the Carpathians, the mean multi annual snowstorms days is low (1 – 2 days/year) (Bogdan, Niculescu, 1999). The area is situated in the mixed vulnerability regions, as a resulted from the combination of low vulnerability in the depressions and the high vulnerability in the high altitudinal areas (Fig. 11).

Lightings – the number of lighting days specific to mountain regions is 35 – 40 days/year. In the studied area, the maximum number of annual lightings days is 69 in Câmpeni and 70 in Băişoara (Fig. 4.11) (RMGC, 2006).

4.2. Hydrologic hazards

4.2.1. Floods in the Arieş River middle basin

The magnitude and characteristics of a flood depend greatly on several factors, of which the most important are the climate and morphometric ones, characterizing the hydrographic basin and the water course.

The high altitudes and the oblong form of the river basin are conditional factor, favoring floods. On the other hand, the large catchments basin area and low slope of the terrain and water courses are factors supporting flow regularization and thus, prevent floods. The predominance of crystalline and magmatic rocks favors the flow, and indirectly, floods, while the soils characterized by a short profile, middle texture and the dense vegetation favor drainage and reduce water speed.

April is the spring month characterized by the highest flood frequency, because there are more favorable situations: snow melt from the higher regions, heavy rainfalls, full riverbeds, low evapotranspiration, soil saturated with water, incomplete vegetation development. During summer, there are high intensity and duration (Croitoru, 2006). There are usually heavy rainfalls, which fall locally and isolated, but which produce high flow rates. The maximum precipitations in the cold season are caused by the Western circulation (Arghiuş, 2008). The subtropical air masses cause heavy precipitations and the sudden melting of the existing snow layer. Even if this flood occurrence type is specific to the upper Arieş basin, it can influence the Baia de Arieş and Buru areas, where the waters flowing from upstream concentrate.

Based on these elements, the areas exposed to flood risks were analyzed. The communes in the studied area are exposed to flood risk. The most vulnerable areas to the natural flooding are Lupşa, Bistra and Baia de Arieş communes, which are flown across by many rivers. As to torrential flow, the most affected communes are Sălciua, Ciuruleasa, Bucium, Băişoara and Valea Ierii, because they are situated in areas with slopes which favor the occurrence of the process. The areas affected by slope flows are more frequent than those affected by river floods, because on the main water courses there were built safety embankments, to prevent flooding.

4.2.2. Vulnerability assessment to floods

Applying the *Pressure and release – PAR model,* created by Blaikie, in 1994, the main causes, the dynamic pressures and the unsafe conditions which can influence a community's vulnerability can be identified (Fig. 12).

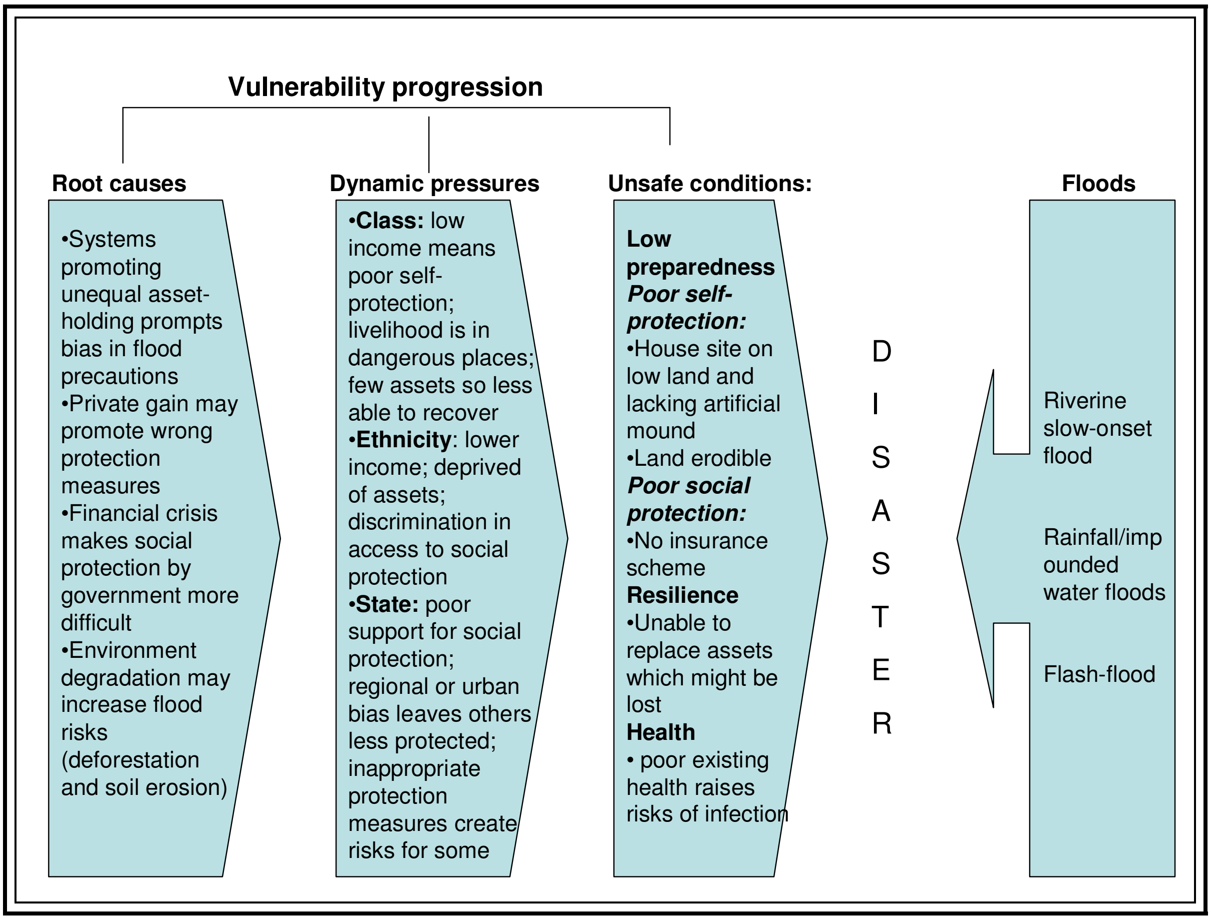


Fig. 12. Pressure and Release Model applied to floods

In the specific case of floods, the root causes are associated to flood prevention and protection works. Within all regions, including the studied one, these works are developed in a selective manner, according to several factors: the most flood affected areas, river bed characteristics, authorities' financial availabilities etc. Thus, some communities are more protected than others: Câmpeni, Baia de Arieş and Iara. Also, within the same commune or village, some groups are more protected than others. Another very important root cause is the lack of funding. Many times, due to financial reasons, there are no flood prevention measures implemented, which could reduce significantly the consequences of a flood.

The dynamic pressures include those processes which transform the root causes in unsafe conditions. They can be divided in several categories: standard of living: smaller incomes means the lack of individual protection, fewer goods and a lower recovery capacity; religion: smaller incomes, fewer goods, restricted social protection access; government: reduced social protection;

implementation of inadequate measures, supporting some regions, while disfavoring others. All these factors influence significantly the communities' vulnerability to floods.

Unsafe conditions include all the forms through which the vulnerability is expressed in the field. At the level of the Arieş middle basin, this vulnerability is expressed through the large number of houses situated in the rivers' flood plains and the river banks' erosion. As to the entire community as a whole, the lack of an efficient assurance system influences the most the vulnerability expression in the field. The poor economic situation specific to the communities in the studied region reduce their resilience. In case of a significant flood, the population will recover, including rebuilding the houses and recovering the goods, in a longer time and with sustained efforts.

From the above mentioned it can be clearly concluded that the studied area is exposed to a relatively significant flood risk. The population in the region is more vulnerable, as these floods affect poor groups, without protection possibilities. The authorities aimed at implementing some prevention and protection measures against floods, by building safety embankments, banks consolidation, slope stabilization, river beds recalibration.

The floods unpredictable character is reduced by short – term hydrologic prognoses (days or weeks). These prognoses' precision (on short – term: 3 to 12 hours) can reach 90%. The data obtained from the automatic hydro – meteorologic stations allow the characterization of the spatial and temporal elements specific to flood, which determines a high precision (even minutes) for the highest waters. Nevertheless, floods represent risks which can effect, having severe consequences, numerous communities and the environment and therefore, the implementation of adequate protection measures is needed.

4.3. Geomorphologic hazards

4.3.1. Rock fall

In the studied region, the areas exposed to rock fall risk are the mountain areas and the mining areas in Abrud, Roşia Montană and Iara. Within these mining perimeters, new anthropic relief forms were created: open pits, waste dumps, anthropic slopes, roads cut along the contour line, which modified the natural relief forms and influenced the occurrence of mass or individual rock falls. The geomorphologic processes (landslides and rock falls) can affect the villages situated in the vicinity of the mining exploitations.

The debris slide associated to rock falls is characteristic to mountain and karst areas, sometimes leading to access roads blocking. The areas potential affected by rock falls are situated within the following communes: Baia de Arieş, Câmpeni, Bistra, Bucium, Ciuruleasa, Lupşa, Ocoliş, Poşaga, Rimetea, Roşia Montană, Sălciua, Valea Ierii, Iara and Băişoara. Rock falls affect county road and even national roads, like in the case of Muncel and Brăzeşti villages (Baia de Arieş). To prevent these rock falls and to protect roads and the population, stabilization works were undertaken, by using wire nets.

4.3.2. Landslides

The declivity specific to mountain steep edges can also be noted in the case of anthropic relief forms within the mining exploitations: open pits cornices (Roşia Poieni and Cetate – Roşia Montană open pit), waste dumps embankments (Valea Verde, Obârşia Muntari, Geamăna, Valea Cuibarului waste dumps) and the fall cones within the Afiniş mine (Baia de Arieş) (Gligor, 2005).

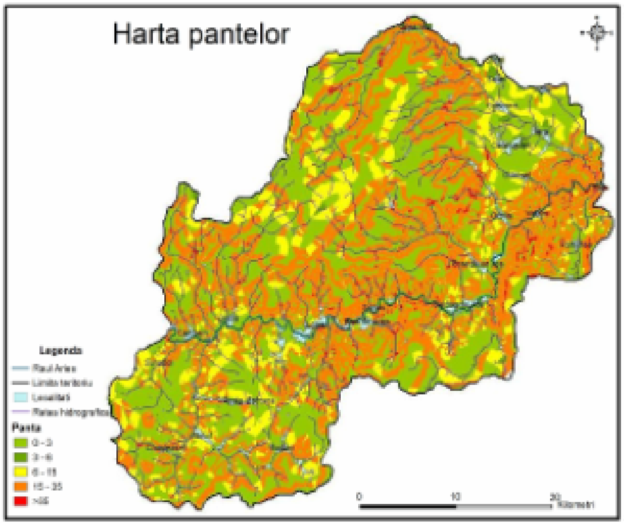


Fig. 13. Slope map

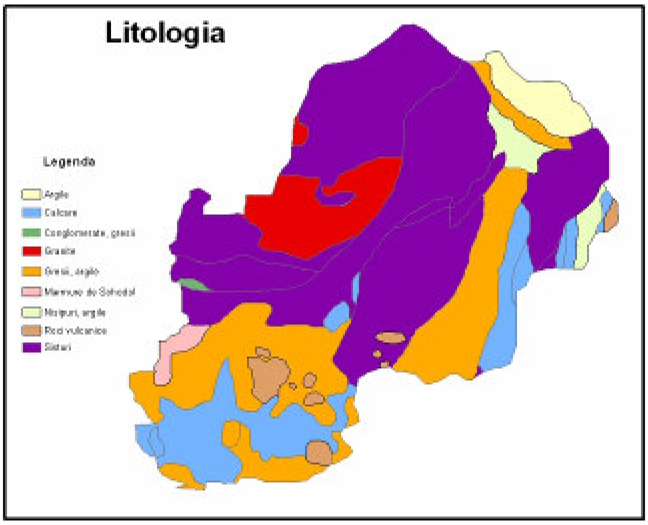


Fig. 14. Lithology

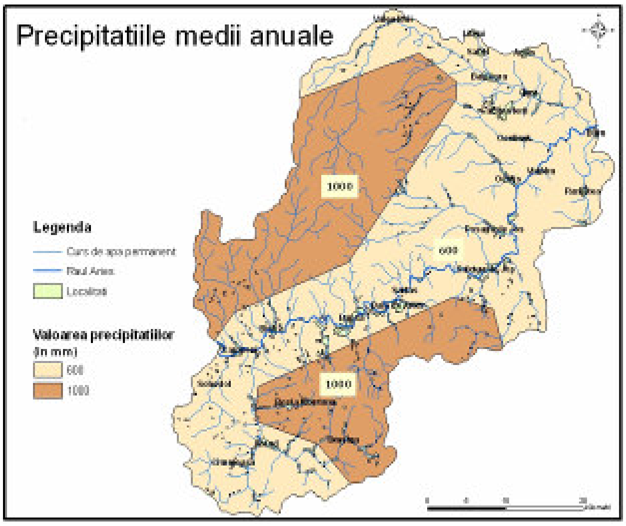


Fig. 15. Annual mean precipitations

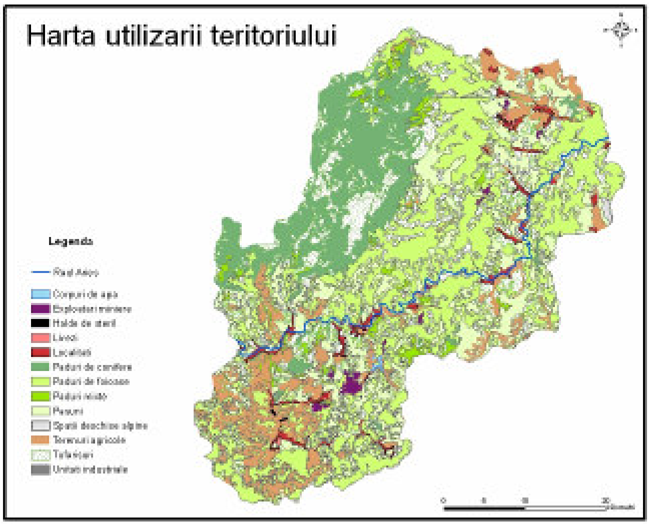


Fig. 16. Land – use map

The elaboration of the landslide susceptibility map, meaning the spatial occurrence probability of landslides, was based on the Guide for the elaboration of landslides risk map for assuring building stability – indicative GT-019-98 (I.S.P.I.F., 1998).

By combining the slope, lithology, annual mean precipitations and land – use maps (Fig. 13, 14, 15, 16), using the Map Calculator in the ArcGIS 9.3 programme, the following landslide susceptibility map was created (Fig. 17). The indexes values vary between 0 (the minimum value) and 0.36 (the maximum value) (or 0 to 36% probability of landslide occurrence) and they were divided in three probability classes. Thus, the three landslide risk categories, according to indicative GT-019-98 are:

- *Insignificant landslide risk areas*. These areas cover wide spatial surfaces (for example, Muntele Mare, Câmpeni, Lupşa, Sălciua and Iara depressions, along the Rimetea, Iara and Bistra valleys etc.). The spatial extension is correlated to the presence of rocks resistant to external factors (granites, crystalline schist, marble and volcanic rocks), doubled by the forests extension (coniferous, broad – leaved or mixed forests);
- *Low landslide risk areas* cover small surfaces, in the Trascău and Metaliferi Mountains, Abrud, Poşaga and Ocoliş depression. These areas are characterized by small sloped and precipitations of 600 mm, the stability being influenced also by the land use (mainly agricultural land);
- *Moderate landslide risk areas.* The presence of moderate landslide risks is mainly determined by the land use (agricultural land, meadows), correlated to the presence of rocks favoring

landslides (sands, clays). Furthermore, the stability is influenced by the heavy precipitations. These areas can be found in Poşaga and Ocoliş depressions, in small areas in the Metaliferi Mountains, Southern Trascău Mountains and overlap most of the mining areas.

The three stability classes are represented on the landslide susceptibility map (Fig. 17).

According to Law no. 575 from 2001, regarding the approval of the National Landscaping Plan – Section V – Natural risks areas, there are several administrative units affected by landslides: Câmpeni – 15 ha, Baia de Arieş – 8 ha, Abrud – 5 ha, Bucium – 31 ha, Ocoliş – 5 ha, Poşaga – 7 ha, Rimetea – 40 ha, Roşia Montană – 50 ha, Făgetul Ierii – 20 ha. In Bistra, Ciuruleasa, Lupşa, Sălciua, Iara, Băişoara and Valea Ierii communes, it is considered that the landslide risk is secondary.

It can be stated that there are evident similiraties between the obtained results (the landslide susceptibility map) and those in the specific legislation.

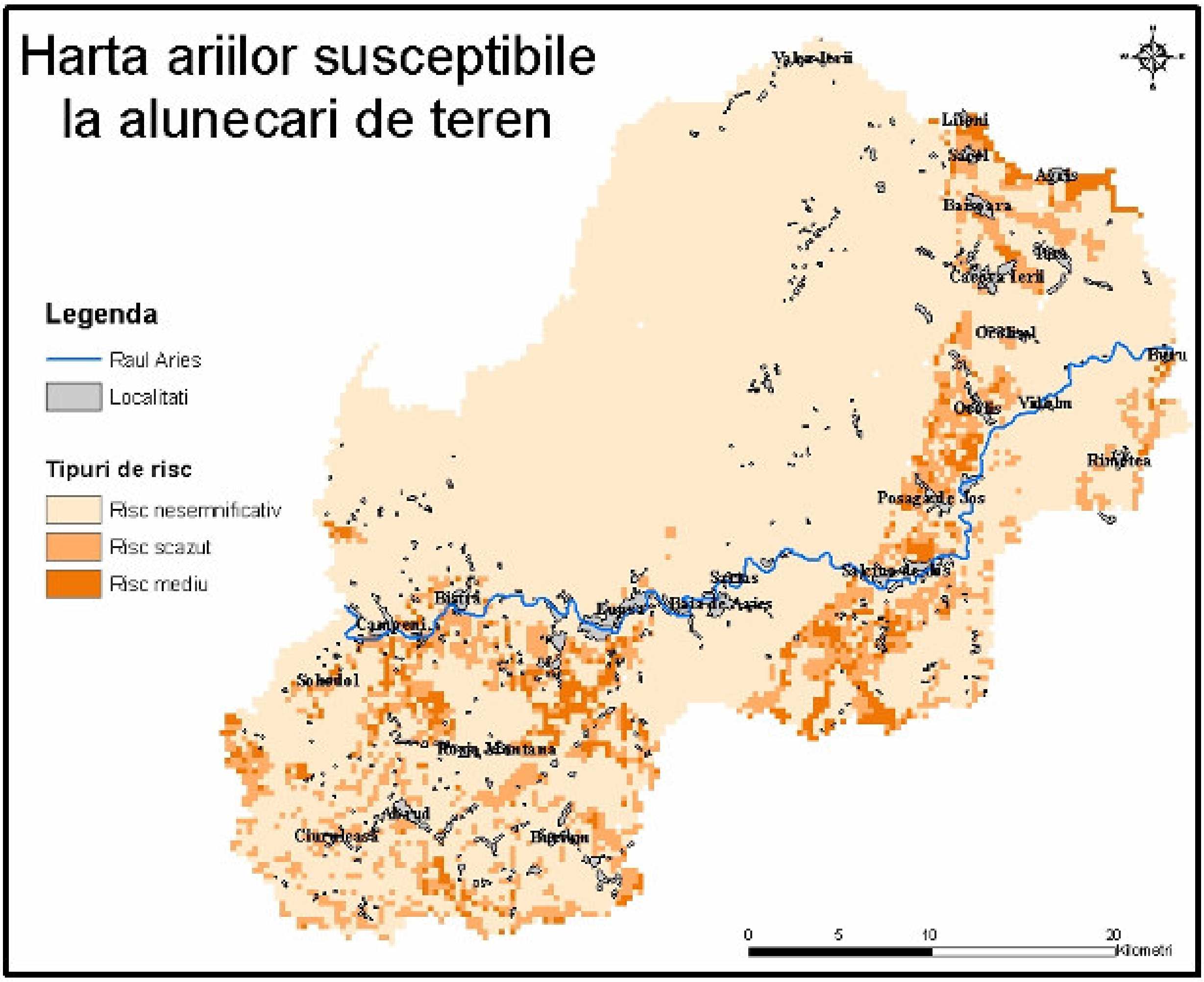


Fig. 17. Landslide susceptibility map

4.3.3. Water erosion

The most intense erosion can be seen during the heavy precipitation months: May to August. The erosion effect is emphasized by the lack of vegetation, as in the case of the deforested or overgrazed (Roşia Montană, Baia de Arieş) and mining areas (Bucium, Roşia Poieni).

The gully erosion affects large surfaces in the studied region Baia de Arieş – 20 ha, Câmpeni – 30 ha, Abrud – 15 ha, Bistra -40 ha, Bucium – 20 ha, Ciuruleasa – 10 ha, Lupşa – 50 ha, Ocoliş – 40 ha, Poşaga – 50 ha, Rimetea – 20 ha, Roşia Montană – 30 ha, Sălciua – 50 ha, Sohodol – 10 ha, Valea Ierii – 6 ha. Most cases, these erosion affected areas are situated at far from the villages, which are therefore not affected by their consequences.

CHAPTER 5
TECHNOLOGIC RISKS IDENTIFICATION AND ASSESSMENT

The mining activities developed in the Arieş middle basin affected this region from many points of view: natural, economic and social. The activities associated to mining industry, either the exploitation itself, or those associated to mine closures, represent a significant risk source, for the environment and for the local population. The gold – silver and copper mining exploitation modified permanently the relief forms, having profound negative consequences on local and regional level.

5.1. Risk associated to mining industry

The Arieş middle basin partially overlaps the Golden Quadrilateral in the Apuseni Mountains. The ores were exploited by four mining industries:

- S.C. Cupru Min S.A. Abrud (copper),
- S.C. Minvest S.A. Deva, Roşiamin Roşia Montană Branch (non - ferrous),
- S.C. Minvest S.A. Deva, Arieşmin Baia de Arieş Branch (non - ferrous),
- S.C. Minvest S.A. Deva, Iaramin Iara Branch (ferrous and non metalliferous), the last three belonging to the Copper, Gold and Silver National Company Deva

All the exploitations are currently closed.

5.1.1. Baia de Arieş Mining Exploitation

The main activity in Baia de Arieş was the exploitation of two ore types: lead – zinc ore and gold – silver ore, through horizontal and vertical mining works. Also, the golden concentrated were secondary processed here (Fig. 18).

The tailings were stored in eight waste dumps and four tailing dams. The activity ceased in 2004, but there were no monitoring activities of the environmental impact produced by the tailing dams' preservation works. Further more, when closing the process plant, the used cyanides were not neutralized.

Geomorphologic speaking, the mining activities modified the landscape, by building waste dumps, by reactivating slope processes and by unbalancing the topographic surface in the fall cones area.

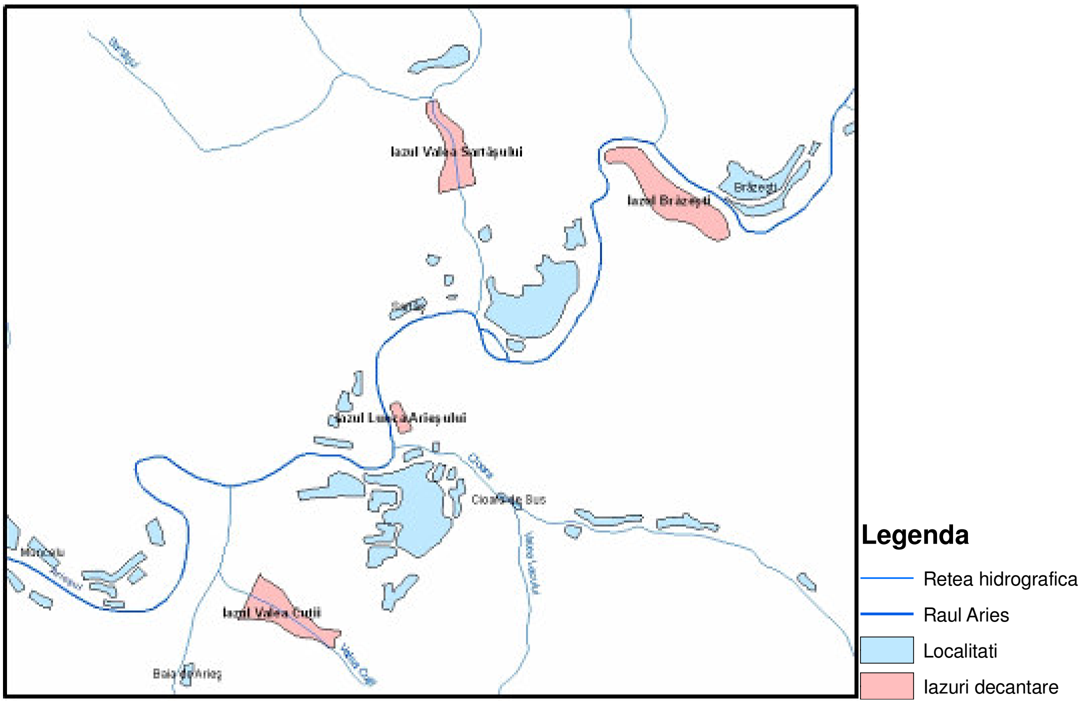
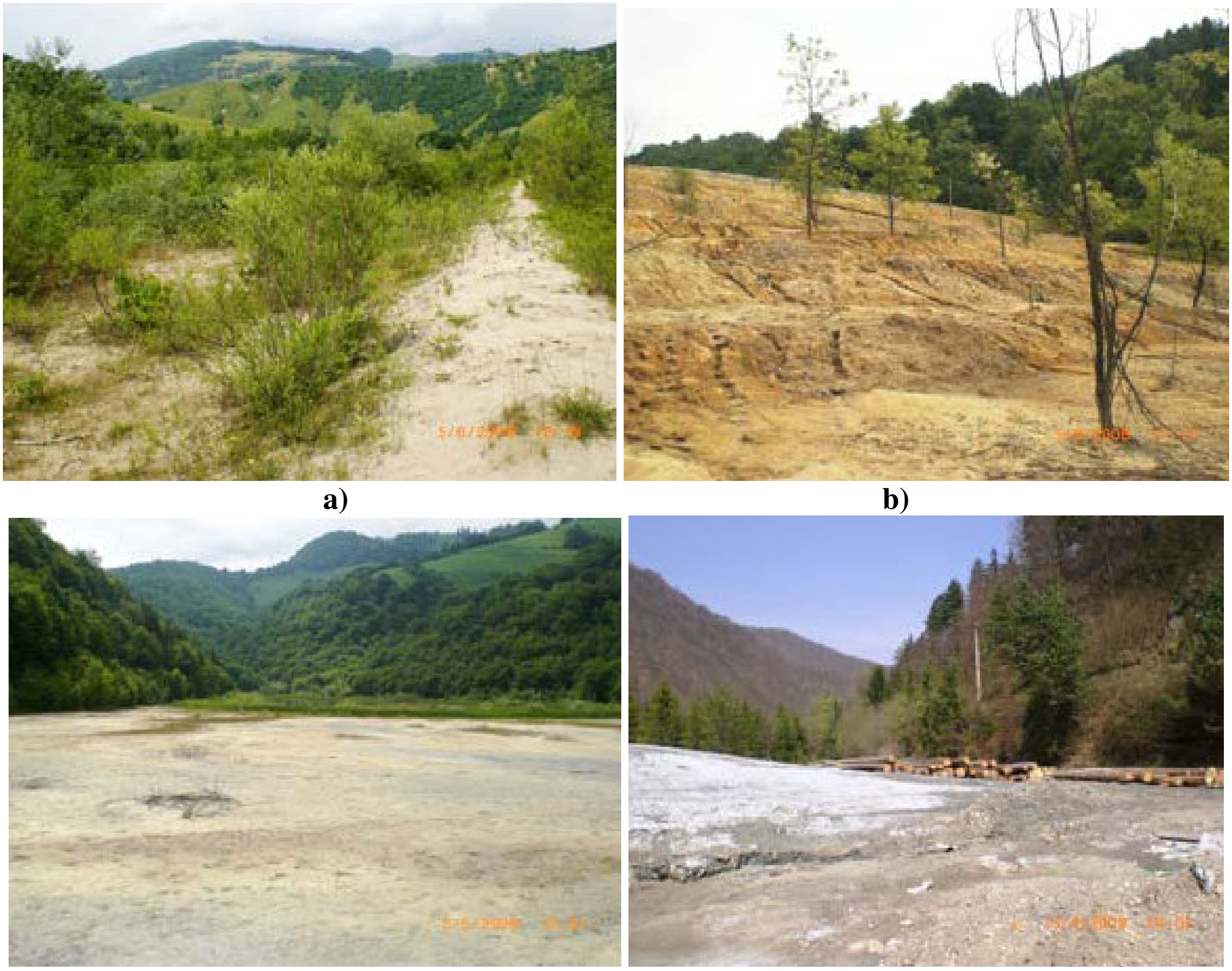


Fig. 18. The location of the tailings dams from Baia de Arieş mining exploitation

The four tailing dam are under preservation. Valea Sartăşului tailing dam is situated downstream Baia de Arieş and it was operational until August 2004. On its sloped there can be observed small ravines and other surface erosion processes (Ministerul Mediului, 2007). Valea Arieşului tailing dam has a 2.8 ha area, is situated in the Arieş flood plain and it is under preservation. Brăzeşti tailing dam is also under preservation, is situated in the Arieş flood plain and is covered in spontaneous vegetation, being stabilized. The top plate and the slope were planned or spontaneously revegetated, and the vegetation includes herbaceous associations, scrubs and trees. However, the Cuții tailing dam, with an area of 3.8 ha, is not stabilized (Fig. 19).



a) b) c) d)

Fig. 19. Tailing dams belonging to Baia de Arieş mining exploitation
a) Brăzeşti tailing dam; b) Sartăş tailing dam; c) Valea Cuții tailing dam; d) Valea Arieşului tailing dam (Ministerul Economiei şi Finanțelor, 2008)

Air pollution was generated by the flotation dust and reactives. Dust contains SiO_2, which had an immediate negative effect on human health. Baia de Arieş town was affected by the nitrogen oxides used as flotation reactive, including sodium cyanide, coming from the concentration storage facilities, situated in the town's neighboring.

Downstream the tailing dams there was a water treatment plant, but which function at inadequate parameters. Thus, the water discharged in the Arieş River, although treated, contained suspensions, sulphates, cyanide and metals (copper, lead, iron, zinc) in quantities exceeding the maximum admissible limits. Currently, the Arieş river water is polluted by the waters coming from the tailing dams. Downstream of Baia de Arieş town, the Cu, Zn, Pb and Cd concentrations exceeded the maximum values imposed by legislation, in two consecutive years (2006 - 2007), even three years after the ceasing of the mining activities (Ozunu et. al, 2009a).

The results of the qualitative risk analysis indicate that the risk associated to mining activities, even after their closures, are moderate or high. The high risk scenarios include the waste dumps slides and tailing dams' failure. The high value is given especially by the consequences one of these scenarios could have on the local communities and environment.

To prevent these to types of accidents, the continuous monitoring of the waste dumps and tailing dams is needed, for the timely identification of any failures, which could allow an adequate intervention.

5.1.2. Roşia Montană Mining Exploitation

Gold was mined at Roşia Montană even from Roman times, the village being known as Alburnus Major. In modern times, Roşia Montană mining exploitation was founded in 1852, using open and underground works. Until 2006, when the activity was closed, the gold ores were exploited in the Cetate open pit, and the processing was undertaken at Gura Roşiei (Fig. 20).

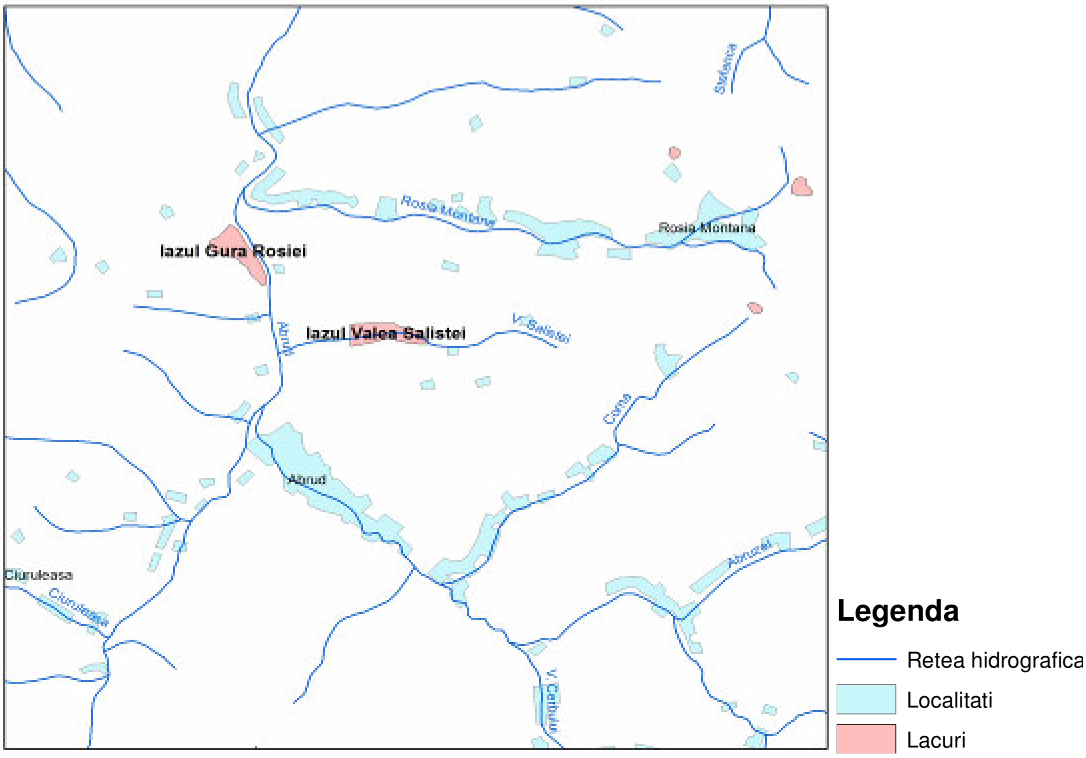


Fig. 20. Location of the tailing dams from the Roşia Montană mining exploitation

There are 17 waste dumps, with a total area of 13.14 ha. Among these, the most important are Valea Verde and Hop. These two waste dumps have a reduced stability level.

The flotation tailings resulted from the ore processing in Gura Roşiei plant was stored in Valea Săliştei and Gura Roşiei tailing dams. Valea Săliştei tailing dam is a valley dam, and on the slopes there can be observed small ravines and rills (Ungur, Negruţ, 2007). Gura Roşiei tailings dam has an area of 24.92 ha and is currently under preservation, being kept as a spare in case of an accident in Valea Săliştei tailing dam. On the sloped there are gully erosion processes, slides and ravines (Muntean et. al, 1998).

Fig. 21. Acid mine waters in Roşia Montană rivulet Fig. 22. Acid drainage, Valea Săliştei tailing dam

Mine waters have a strong acid character and high concentration of metals: lead, zinc, cadmium, iron (some of them exceeding the maximum admissible values) (Florea et. al, 2005) (Fig. 21, 22).

Industrial water is contaminated with suspensions, sediments, sulphates, iron, manganese, zinc and has acid character (Bătinaş, 2006b). Because of these contaminates, the fauna and vegetation from the Roşia Valley have disappeared, and the drinking water fountains were abandoned. Currently, three years after the mining activities were closed, the significant water pollution can still be observed.

The results of the qualitative risk analysis indicate that most of the identified scenarios have high occurrence risk. The high risk scenarios include the inadequate water treatment, waste dumps slide, acid mine drainage and tailing dams' failures. The highest value was calculated for the waste dumps slides, because their stability is very low, and the consequences such an accident could have on the environment are significant.

The prevention measures regarding acid mine drainage include the installation of a semi passive lagoon treatment system and the continuous monitoring of the chemical composition of the effluent. To prevent these accidents the continuous monitoring of waste dumps and tailing dams is needed, for the early identification of any failures, to allow a timely and adequate intervention.

5.1.3. Roşia Poieni Mining Exploitation

The Roşia Poieni ore comprises 64.5% of the total Romanian copper reserve (Vătăjelu et. al, 2005). It is the largest unit of minerals exploitation in Romania and one of the largest in Europe (Fig. 23).

The Abrud mining exploitation's main activity was the exploitation of copper from the Roşia Poieni ore and its processing through the classic flotation technology, to obtain concentrates with 16.5 – 22% copper. The ore was discovered following the geologic, geochemical and geophysical research programmes, in the 60's and 70's (Milu et al., 2004).

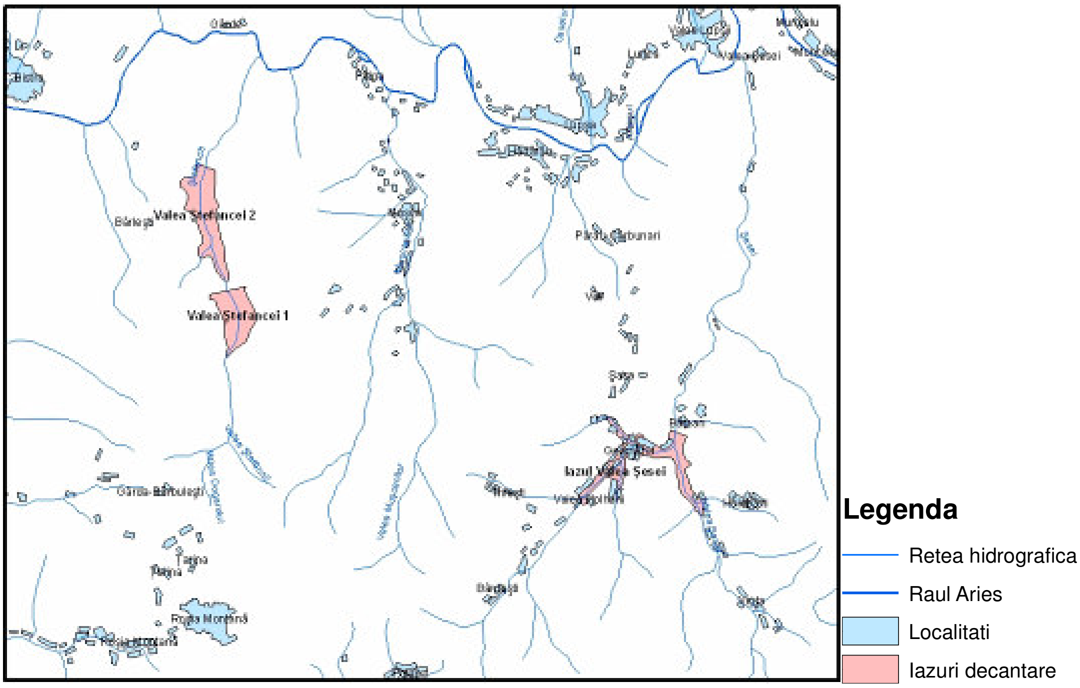


Fig. 23. Location of the tailing dams from the Roşia Poieni mining exploitation

On the three waste dumps slopes (Obârşia Muntari, valea Cuibarului and Geamăna) gully erosion processes can be observed, especially in the inactive areas. The storage platforms were built against the regulations, therefore the precipitation water stagnates or flow to the contact between the tailings and the versant, which can lead to the dump's slide (Ipromin, 1999). Also, the embankment angle has a high value, which determines a low stability.

Fig. 24. Roşia Poieni open pit

Fig. 25. Roşia Poieni waste heaps

Valea Şesei tailing dams was used by the Roşia Poieni processing plant. The dam was elevated in 2008, for its safety (Luca et al., 2006). The dam has no drainage system, therefore the water quality indicators are often exceeded.

Valea Ştefancei I tailing dam is situated in Lupşa commune, having the dam at approximately 3 km from the confluence of the Ştefancei rivulet with the Arieş river. (Duma, 1998). There are no stability issues (Ministerul Mediului, 2007).

The pollutants evacuated in the atmosphere were mainly SO_2 and NO_2 dusts. The maximum pollution periods happen during dry seasons, when a dense fog can be observed above the open pit. The dust particles are carried by wind from the embankments and upper plates, especially during dry and windy days.

Steregoi, Cuibarului, Muntari and Şesei rivulets upstream their flow in the Valea Şesei tailing dam are heavily polluted, having a strong acid character. The waters are contaminated with Cu, Fe, Zn, Mn ions and solid suspensions, in concentrations high above the admissible limits. These rivulets' pollutions are generated by the waters draining from the acid waste dumps, which have heavy metals ions and solid suspensions (Vătăjelu et. al, 2005).

The waters discharged from the tailing dams flow into Valea Şesei and Valea Ştefancei rivulets and then in Arieş river. These waters have a strong acid character and concentrations of Cu, Fe, Zn, Mn which exceed the admissible limits (Milu et. al, 2002). Therefore, the Arieş water is contaminated, due to the used water discharges from the Roşia Poieni mining exploitation. The immediate effect was the complete disappearance of aquatic life.

The results of the qualitative risk analysis indicate that the risk associated to mining activities, even after their closures, are high. The high risk scenarios include the inadequate water treatment, the waste dumps slides, acid waters drainage and tailing dams' failure.

The prevention measures regarding acid mine drainage include the installation of a semi passive lagoon treatment system and the continuous monitoring of the chemical composition of the effluent. To prevent these accidents the continuous monitoring of waste dumps and tailing dams is needed, for the early identification of any failures, to allow a timely and adequate intervention.

This exploitation was recently closed (March 2009) and there were no closure or rehabilitation measures implemented. Thus, the accident probability is higher, and the mining activities consequences on the local community and on the environment can be observed now and in the future.

5.1.4. Iara Mining Exploitation

The siliceous sand deposit is situated in the Făgetul Ierii area, in the Iara commune. The sand exploitation was closed in 2006.

The Valea-Lita complex ore was considered unprofitable, economically speaking. Thus, the Iara mining exploitation has as main activity the iron ore exploitation from the other two deposits: Maşca-Băişoara and Cacova Ierii.

The Cacova Ierii deposit comprises iron mineralization, only subordinate polymetallic mineralization (Lucăcel, 2008). Because of its unprofitableness, its exploitation is now closed.

The Maşca-Băişoara deposit comprises iron mineralization. The deposit was economically exhausted, currently the last phase of the closure process being undertaken.

The Iara mining exploitation was founded in1972, belonging to the former Mining Group Cluj. Because of the small economic value of the Valea-Lita deposit, the activities consisted of iron ore exploitation from the Maşca – Băişoara and Cacova Ierii deposits. Since 1982, this exploitation comprises the sand exploitation from Făgetul Ierii.

In 2006, the Iara mining exploitation was closed.

Băişoara tailing dam has a total area of 8.50 ha and a total volume of 3.33 mil. m^3. The storage was ceased in 1975. Făgetul Ierii tailing dam has a total surface of 5.84 ha and a total volume of 1.56 mil. m^3 (Ministerul Mediului, 2007). Both tailing dams are currently under preservation (Fig. 26).

The analysis indicated that the maximum legal concentrations of water pollutants are not exceeded. The measurements were performed upstream and downstream of the discharge points in the Iara River. However, during precipitation, water can carry quartz sand or tailings, which reach the Făgeţel and Părului rivulets, generating their silting.

Soil is the most affect environmental factor, especially due to the large surfaces occupied by the mining activities and which were removed from the agricultural circuit. Furthermore, the cavities generated by the ore exploitation can trigger land falls, leading to the extension of unfertile land surfaces (Minesa, 2008).

Fig. 26. Gully erosion on the Băişoara tailing dam embankment

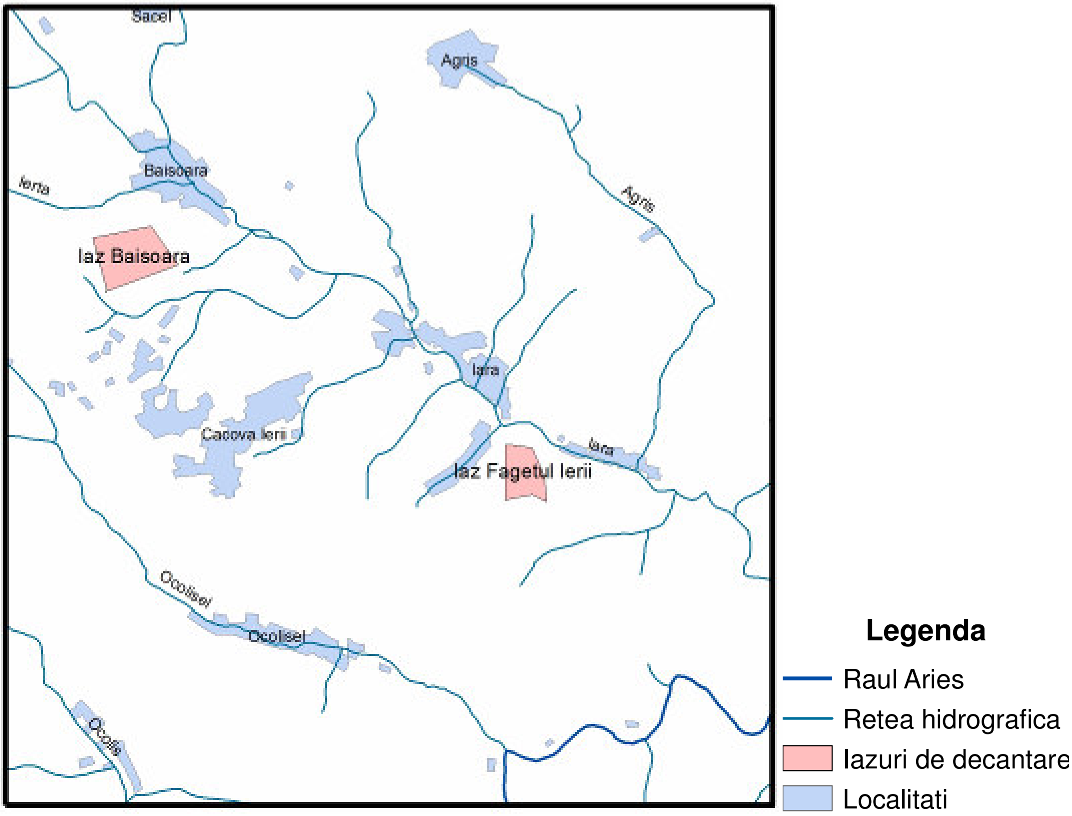


Fig. 27. Location of the Iara mining exploitation tailing dams

The qualitative risk analysis results indicate that the majority of the identified scenarios have a moderate risk probability. The tailing dams and waste dumps are currently under preserved and stabilized, which reduces this accidents probability risk.

The other anthropic activities in the area (wood exploitation, agriculture, breeding, transport activities, textile industry, tourism etc.) have minor risks and a low impact on the local communities, especially due to the small scale.

CHAPTER 6
SOCIAL VULNERABILITY ASSESSMENT

The Arieş middle basin represents a territorial unit with certain physical, economic, demographic and cultural features.

From the administrative point of view, the Arieş middle basin included 3 towns: Abrud, Câmpeni and Baia de Arieş and 13 communes: Bucium, Bistra, Băişoara, Ciuruleasa, Iara, Lupşa, Ocoliş, Poşaga, Roşia Montană, Rimetea, Sălciua, Sohodol, Valea Ierii. Three of them (Băişoara, Iara, Valea Ierii) belong to Cluj county, and the rest of them belong to Alba county.

The socio-economic and natural potential assessment refers to those characteristics of the studied region which concur to vulnerability reduction. The socio – economic and natural potential comprises all the elements which can support the local community in coping with or recovering after a disaster. The potential value is used in assessing the total vulnerability: the higher the socio – economic and natural potential, the lower the community's vulnerability.

To assess the socio – economic and natural potential and to identify the highest vulnerability level group, the model elaborated by Raţiu (2007) was used, modified according to the data availability and region characteristics. To establish the socio – economic and natural potential, the elements regarding the demographic characteristic of the area, the location characteristics and the natural and technologic risk were considered.

Depending on the socio – economic and natural potential, the localities ranged on a large scale, having values between 168 and 24. According to the obtained values, the localities were divided into four classes:

a) **Very low vulnerability level class** – This means a very high socio – economic and natural potential. In this class the Câmpeni and Abrud towns and Bistra commune are included, because their values were higher than 100. These values resulted from the demographical structure: high number of inhabitants, high number of active population. Furthermore, two are towns, and Bistra commune are situated in the vicinity of Câmpeni and Baia de Arieş, which represents more varied development possibilities. The two towns, Câmpeni and Abrud are protected against floods by safety embankments.
b) **Low vulnerability level class** – includes the localities with potential values between 70 and 100: Iara, Baia de Arieş, Lupşa and Roşia Montană. Iara commune has the highest potential, due to its high inhabitant's number. This commune's potential value exceeds the Baia de Arieş's potential value, because of this high demographic potential. Furthermore, both units have flood protection works, which represents a plus in the total potential. Both units are affected by mining activities, which reduces the total value. The main difference is given by the human resources. This class includes Lupşa and Roşia Montană communes, due to their high demographic potential. The two communes have a similar inhabitant's number and are situated in the vicinity of Baia de Arieş town and Abrud town, respectively.
c) **Moderate vulnerability level class** – includes 6 communes, with potential ranging from 30 to 70. This class comprises most of the units in the studied region (37,5 %). In obtaining these values, all element categories participated in equal proportions. These communes have similar inhabitants number, being small and medium communes. The human resources were the most important in the case of Băişoara and Sohodol communes.
d) **High vulnerability level class** – comprises three communes: Bucium, Rimetea and Ocoliş, whose potential values are smaller than 30. In the cases of Bucium and Rimetea communes, the demographic potential was relatively high. Bucium commune can be affected by mining activities developed nearby, while the Rimetea commune can be affected by rock falls from the steep slopes. Ocoliş commune has the lowest socio – economic potential and thus, the highest vulnerability level (Fig. 28).

Within the Arieş river basin, the demographic characteristics, meaning the high feminine and elder population proportion, determines a high social vulnerability level. These two social categories have low and insecure incomes and have a reduce capability to respond to an emergency situation. Also, they have difficulties coping to the changes from the economic environment.

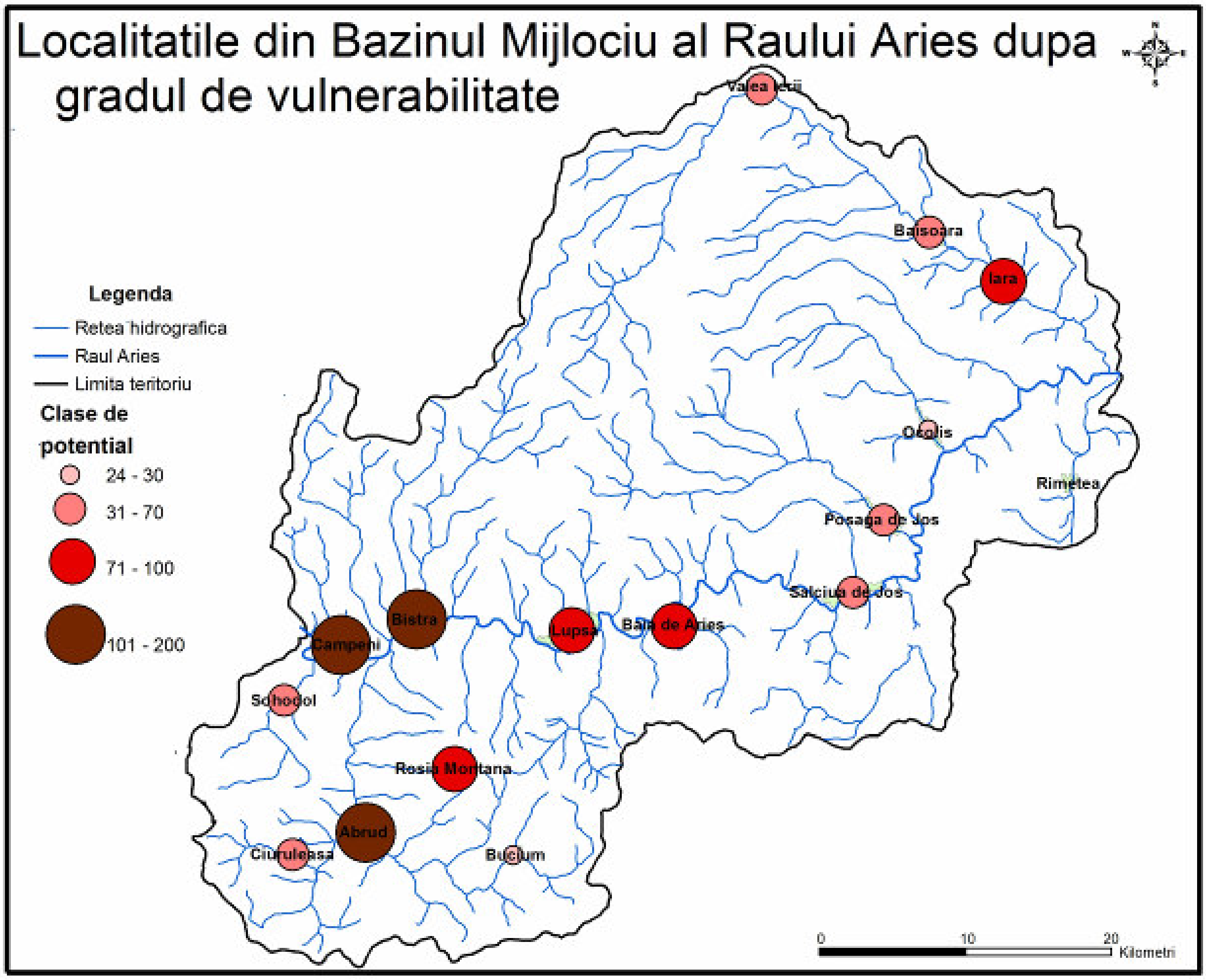


Fig. 28. Localities in the studied area, depending on the socio – economic and natural impact

Another factor stressing the social vulnerability is the dependency on the mining industry (Costache, 2009). This industry represented a secure income source for a long period of time and for a large part of the population. The mining industry restructuring process, meaning in fact the mines closure, lead to the retiring of many employees or their unemployment. Thus, the unemployment rate increased, and the incomes in the entire region decreased. The high poverty level determines a high social vulnerability, because the poor population is not capable to adapt to the changes in the natural and economic environment (Costan, 2008b). The alternative occupations are directly connected to the environment and its changes. The mono specialization of labor force and the lack of educational systems for professional reconversion make the employment of the population in other activity fields very difficult.

CHAPTER 7
VULNERABILITY REDUCTION METHODS

Reduction refers to deliberate, sustained measures, implemented long before the event took place, to prevent or reduce the impact of hazards and to avoid a disaster (Emdad Haque, Burton, 2005). Vulnerability reduction is made by identifying the points where an intervention can be made from the causal chain between the existence of a hazard and its consequences upon humanity.

Due to the point-like character of the pressures which determine the vulnerability, the policies of its reduction can be very exact and aimed at the most vulnerable groups. At the same time though, regional and international collaboration play a very important role, especially by increasing consciousness nationally regarding the vulnerability reduction policies. In some situations, implementing these policies is very easy and it brings benefits to all involved, but there are cases in which a certain group, individual or society is affected on the short or long term. This means integrating the lessons learned in current policies and the considerations for humanity and the next generations.

7.1. Emergency situations management

Due to the great number of natural and technological disasters which our country confronted with in the past years, a strategy of emergency situations management was elaborated nationally, which could respond efficiently and according to all emergency types. The National System of Emergency Situations Management was set up, based on the Emergency Decree nr. 21, dated April 15th, 2004, in order to provide the resources and to coordinate the actions in emergency situations. This provides the legal background and the existence of certain mechanisms of efficient management, of material and cultural values during an emergency situation in process, and which permit the recovery after an emergency situation.

The professional emergency services, constituted as public services disconcerted under the General Inspectorate for Emergency Situations, are founded in every district in order to manage the emergency situations according to the risk types identified. The professional emergency services function as inspectorates, with legal entity, under the General Inspectorate for Emergency Situations (GD nr. 1492/2004).

As far as the service equipment available, in 2008, the Inspectorates for Emergency Situations in Alba and Cluj have absorbed European funds through the Regional Operational Program, priority axis 3 „Social infrastructure improvement", major intervention Domain 3.3 „The equipment endowment improvement of operational bases for interventions in emergency situations".

The voluntary services for emergency situations were founded in 2005, based on the Decree of the Minister of Administration and Interior nr. 718/2005, for the approval of the Performance Criteria regarding the organizational structure and the endowment of the voluntary services for emergency situations. They act at the level of an administrative unit (village, town or municipality), chosen by their region surface, number of residents, types and gravity of identified risks, transport and utilities infrastructure, means of communication and measures established in the Analysis and risk coverage plan.

In the studied region, the number of volunteers that are part of the voluntary services in emergency situations and are not employed is extremely low. The low number of volunteers that could intervene in case of an emergency situation can be explained by the demographic decline of the population: ageing, feminization and migration. Also, the lack of interest for volunteering may be the fact that it is associated with patriotic labor and that there are no financial rewards (Costan et al., 2008a). In this way there are not enough human resources that could intervene in emergency situations, contributing to the increase in the vulnerability of communities. To attract volunteers, the authorities need to involve themselves in the financing of voluntary services, the aggressive promotion of volunteering at all levels and the education of children in this direction, beginning in the kindergarten or primary school.

7.2. Population prepardness

Being a vulnerability reduction method, population training for emergency situations is of major importance. For its accomplishment, there is a set of methods and plans well articulated and structured, materialized in special laws, elaborated by the Ministry of Administration and Interior.

These come to complete a much more complex process which has as an objective vulnerability reduction, by anticipation and preventing the emergency situations.

Training refers to being aware and assimilating the intervention methods in case of emergency situations, having as purpose the protection of the population, of the environment and of material goods. Another component is training regarding the prevention of this kind of situations. The training or education is being achieved systematically in order to assimilate some physical and intellectual skills.

These training stages are carried out at all administrative levels; there are provided measures of preventing and fighting or decreasing the emergency situations produced by accidental causes or situations caused by conflicts: at district level, local level, public institution and economic operators level, at the level of educational units and institutions and at the level of the representatives of local public administrations.

The training for emergency situations is settled nationally through specific laws and refers to those elements that can protect human life and health in case of a disaster. Unfortunately, in spite of the fact that theoretically this preparation exists, objectively, it is insufficient and it is not completely assimilated by the population. This can be changed by implementing certain strategies and programs which have to have a financial base and sufficient material resources to cover the whole population. Also, the training should be realized through practical and attractive exercises, in which the population is directly involved.

7.3. Regional development

The mine industry in Romania was characterized by the de utilization of old exploiting and processing techniques and by the exploitation of deposits with a low mineral content. Low productivity level and high production costs made the mine industry one of the industries with the greatest losses at a national level, so that closing some mines or restructuring the activities of others was the only viable alternative (Ştefănescu et al., 2008b). One of the purpoes of this process was closing all mines, no matter what their productivity or unemployment rate were, the working force being atracted by the substantial compensatory payments offered. The major disadvantage of the process of mine industry restructuring was the fact that it was only a simple personnel reduction, without taking into consideration the fact that this reduction affected the occupational structure of the mining units and implicitly, the capitalization of the activities (Larionescu et al., 1999). The process developed in a hurry, without considering the local conditions or the future regional development.

The ceasing of the mining activities lead to the decline of all the other industrial activities and in the economic environment, generally. The lack of development alternatives lead to firing employees of other industrial branches. The decline of the mining activity represented an obstacle in the growing process and the economic development of the entire region. The towns situated inside the under-privileged area (Abrud, Câmpeni, Baia de Arieş) lost their polarizing character, once with the economic decline.

Since 1999, the north-western part of Alba district was declared under-privileged area, according to G.D. nr. 813/1999, for a 10-year period. This contains a number of localities in Alba district, amongst which, in the studied region there are situated the villages: Abrud, Ciuruleasa, Bucium, Sohodol, Roşia Montană, Baia de Arieş, Bistra, Lupşa and Sălciua.

The facilities granted for investments in these areas primarily aimed to create new jobs for the unoccupied labour force or for their family members, who live in the under-privileged area and also aimed to attract investors in the area. Moreover, public and private initiative are promoted, there is a tendency to improve the economic and social activity in the area and to regularize the activities during its existence.

Stopping mining activities, reducing the employment rate, the pressure exerted by the high number of unemployed and the labour force monospecialization are some of the factors that contributed to unbalance in the area (Dani et al., 2006). The professional reconversion programs were introduced after the social crises appeared and did not have the expected result. The limited success can be explained by the reduced financial resources and by the low number of jobs associated to new professions. Moreover, the significant financial compensations offered to the discharged mineworkers, many times voluntarily, provoked their loss of interest to find a new job.

In june 2000, the Minister of Development and Prognosis, nowadays the Minister of Regional Development and Housing, started 3 special programs that aim to attract investments in the under-privileged areas. In the studied region, lack of communication with the local authorities and the lack of involvement of the economic agents made that the funds were not used. Consequently, there wasn't any project financed and finalized through these programs.

In 2009, the National Agency for Mining Areas Development was reorganized and became the Romanian Agency for the Durable Development of the Industrial Areas (RADDIA). The agency functions under the Minister of Economy and aims to durably develop the areas affected by restructuring, by managing investment projects. Through RADDIA there were implemented a series of projects:

- "Stimuli chart for employment and training" – financial support for the authorized physical persons and for the legal entities which hire or train unemployed people from the under-privileged areas for at least 12 months. The great number of jobs generated by this program (238) in the studied region reduced the underground jobs and improved the living standard for the employed and their families.
- The Social Development Chart of Mining Communities (SDCMC) aims to reduce poverty and to socially develop the areas affected by mining restructuring.
- The "Municipal Infrastructure" component (MI) aims to finance projects that regard small infrastructure works, but of maximum importance for the mining areas. In 2008, projects for infrastructure development were started in Abrud, Baia de Arieş, Bistra-Poiana, Iara village.
- The Small Grants Chart aims to improve living conditions for the disadvantaged groups from the mining areas: children, young people, women and elderly. In the past 2 years microprojects valued at 326.031 were approved for financing.

Entering the European Union lead to accessing some important unrefundable european funds, destined for regional development. The new funds represent financial support for the development of new small companies or for diversifying the existing ones and it also opens new job opportunities. But the success of these projects depends on the involvement of the authorities and on the development of the infrastructure and of the local business environment, generally.

In conclusion, the possibilities to obtain financing have become more and more numerous and diverse in the past years. Despite the great amount and diversity of financing programs, these funds are insufficiently accessed for the development of the Arieş river middle basin. There are very few projects in process which generally address the development of small companies, social services and of infrustructure modernization. This is caused by the small number of information and consulting activities, weak communication between the ones involved and sometimes, the inefficiency of the projects put in practice. In the future, to access these funds, there is the need for a more active involvement of the local authorities, in parallel with a tighter collaboration between the public sector and the private one.

7.4. Tourism

A viable alternative of vulnerability reduction in the studied region is the economic development of the area. This measure would eliminate the population's financial instability and would lead to durable development of the entire region. Until agriculture becomes profitable, commerce and tourism are considered domains to invest in, and they could be developed in a short time.

The Arieş river middle basin has a high touristic potential, also favoured by the proximity to Austria and Hungary (Cocean, 1984). Apart from touristic landscapes, the touristic model is also based on the cultural background: traditional agriculture, processing of wood, skins, weaving and cooking. Cultural tourism should be also mentioned: old monasteries, small wooden churches with valuable icons, specific costumes and holidays.

In the studied region there is a number of 86 historical monuments included in the Historical Monuments List, approved by the Ministry of Culture and Cults. This List has been approved through the Decree nr. 2314/July 8th, 2004 of the Ministry of Culture and Cults and published in the Romania's Official Monitor, Part I, year 172 (XVI), Nr. 646 bis from July 16th, 2004. Apart from these, there are some locally recognized anthropical objectives.

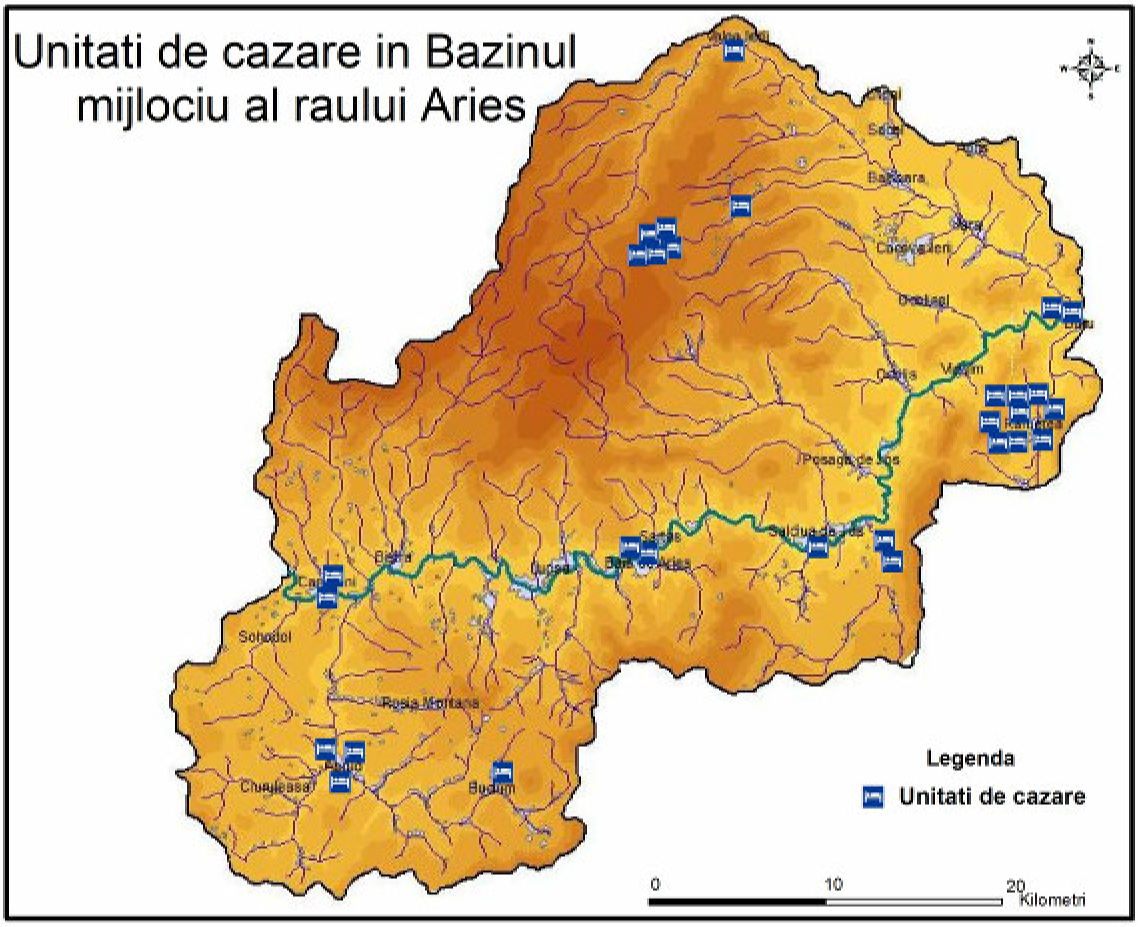


Fig. 29. Map of accommodation units distribution in the region

The number of accommodation units is relatively small (39), relative to the corresponding area (1.406 km^2) (Fig. 29). The accommodation units are unevenly scattered in the region, being concentrated in Rimetea village and in Muntele Băişorii mountain resort. Out of these, only 17, that is 43,5%, are members of the National Association for Rural, Ecological and Cultural Tourism in Romania (NARECT).

The financial resources of the villages are not sufficient for the infrastructure development. That is why tourism could absorb those necessary funds. At the same time, a good infrastructure is extremely useful in case of emergency situations, in order to facilitate the response and intervention actions.

Primarily, tourism would reduce poverty in the local communities, and this would have a significantly positive impact on the vulnerability reduction. Tourism offers numerous job opportunities for the unqualified workers, for the unemployed or for the women, all these representing the most vulnerable groups. Secondly, in this region, tourism is based on the existent natural and cultural resources, which are „goods" of the population, even the poor one, that doesn't have other financial or material resources (Neto, 2003).

Another aspect that has to be mentioned is the land-use planning. Before starting any activity and moreover any touristic activity, there is the necessit to be aware of the hazards and risks which the community is exposed to. The construction of new accommodation units will be realized after analyzing the maps that show the susceptability to land drift or floods, in order to protect the population and even buildings. Moreover, there is the need to elaborate and implement a zoning system that could forbid constructions in certain areas of natural interest to stop construction of vacation houses or hotels without respecting a land-use planning policy.

Once the tourism is developed, the environment protection must be considered. Massive forest clearings that took place lately lead to area damage and favoured floods. Forests must be protected for their landscape beauty and also for their plant and animal species (Abrudan, Turnock, 1999). The forest clearings for road building across valleys lead to earth erosion. Moreover, tourists generate important waste amounts which can become a real problem where there are no corresponding managing systems that could permit the protection of natural resources and ecosystems (Cooper, Hall, 2008).

Tourism should be practised being aware of the preservation of nature and its components, so that the impact on the environment is minimal and the socio-economic benefits are maximal.

Tourism remains one of the few viable alternatives for a future area development, but this is possible only with the local authorities involvement in the implementation of some viable tourism promotion programs and also in the improval of the studied region image in front of potential investors.

CHAPTER 8
THE SYNTHETIC PRESENTATION OF HAZARDS AND VULNERABILITY IN THE ARIEŞ RIVER MIDDLE BASIN

The synthetic presentation and the final map were realized by overlapping the characteristics of all hazards identified in Arieş river middle basin and the socio-human potential specific to local communities, in order to highlight those regions that need intervention measures to reduce hazards impacts and to protect the population.

For the matrix assessment of the risks generated by these hazards, there were taken into consideration the risk generating processes, also the risk degree indicators and the risk category apreciation chart were established. The considered hazards are those identified at the level of the Arieş river middle basin and which can transform in risks with impact on the population and the environment.

Therefore, the four hazards categories were:

- climatic hazards,
- hydrologic hazards,
- geomorphologic hazards and
- mining activities, as an anthropic hazard.

The risk degrees were analyzed, depending on the following risk indicators:

- impact gravity (expressed by magnitude and related to spatial scale and number of affected inhabitans),
- impact persistence (temporal scale),
- cumulative and synergic effects,
- impact probability (Mihăiescu et al., 2003).

In order to establish the general risk degree, the values obtained for natural and anthropic risks generated by hazards were correlated with the socio-human potential values calculated in chapter 6.

The relation between the values obtained from the matrix assessment of natural and anthropic risks and the socio-human potential is in inverse proportion: a high risk value is diminished by a high socio-human potential value. Practically, the risks caused by natural or anthropic hazards are reduced as gravity and consequences through a high socio-human potential.

In territory, risk evaluation was carried out according to the existent administrative-territorial units: towns or villages. To reduce risks, measures should be taken at a communal, district or national level, depending on their gravity. In addition, in many cases there is the need of a strong collaboration between the neighbor units.

For each hazard category a map has been realized, which highlights the affected region according to gravity (Fig. 30, 31, 32, 33).

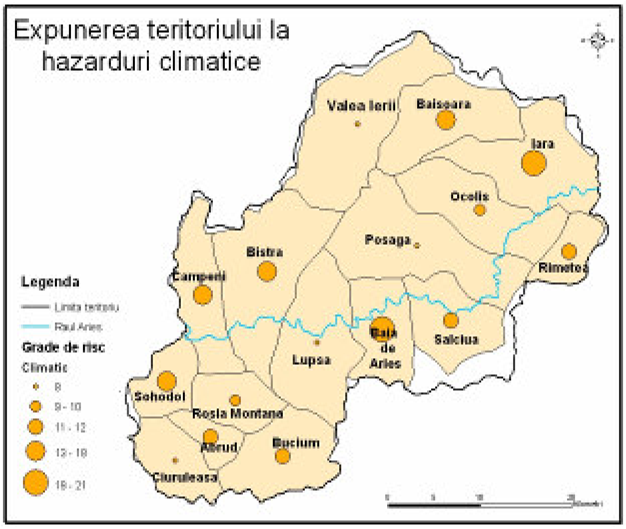


Fig. 30. Map of region exposed to climatic hazards

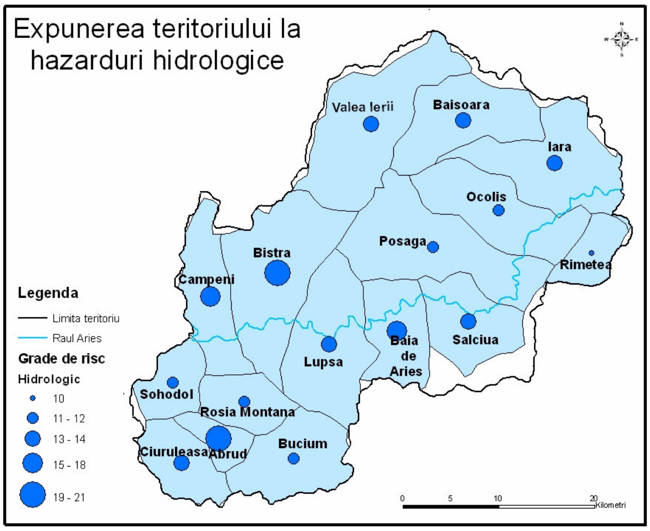


Fig. 31. Map of region exposed to hydrologic hazards

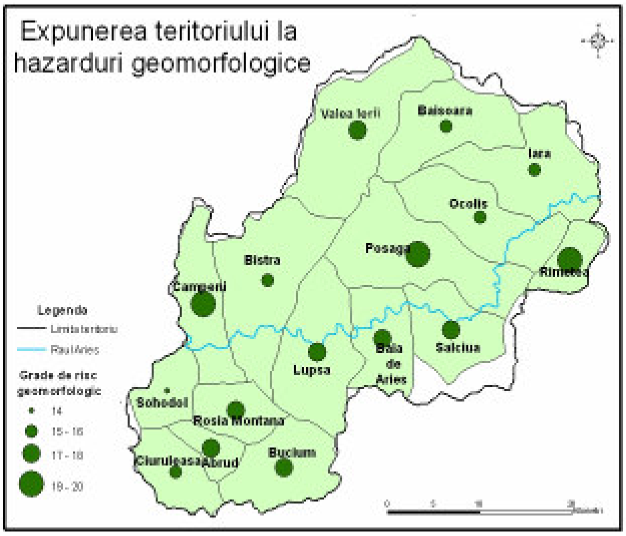


Fig. 32. Map of region exposed to geomorphologic hazards

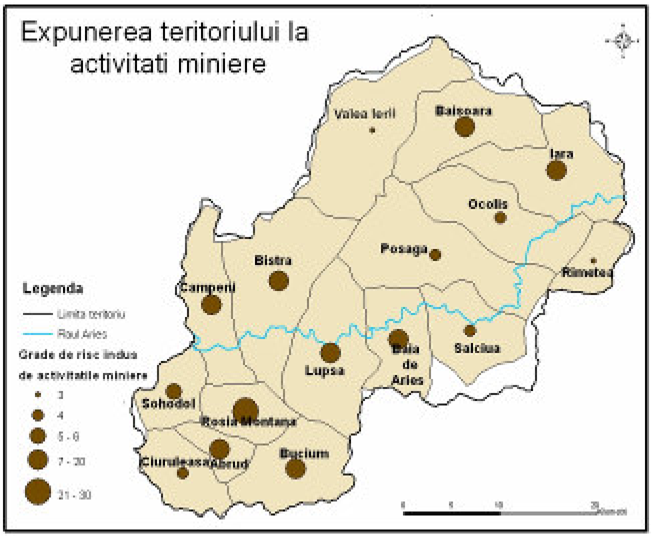


Fig. 33. Map of region exposed to mining activities risk

The obtained results are graphically shown by a map (Fig. 34), which can provide specific information for the vulnerability analysis. Based on what was mentioned, those regions that need a more detailed analysis of the hazards and their effects upon the local communities can be identified.

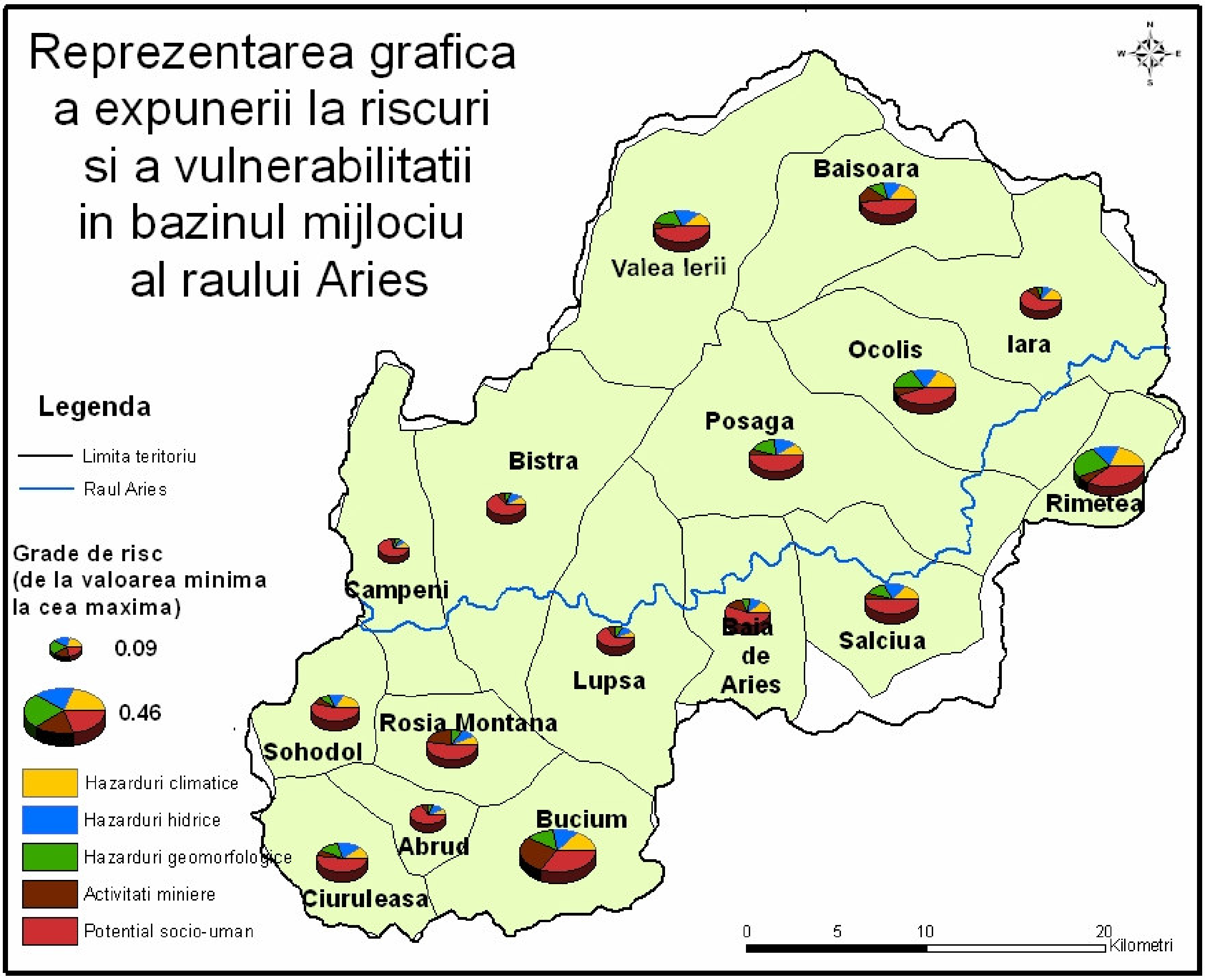


Fig. 34. The graphic presentation of risk exposure and vulnerability of the administrative-territorial units

As we can observe in the results above, the socio-human potential has a major importance; it modifies the hierarchization obtained in the matrix risk assessment. The most exposed communes are Bucium, Rimetea and Ocoliş. If in the Bucium case the total value is given by the gravity and magnitude of natural and anthropic risks (especially those caused by mining activities), as well as by the low socio-human potential value, in the case of the two other communes, Ocoliş and Rimetea, the result is mostly influenced by the low socio-human potential value.

As far as Abrud, Baia de Arieş and Câmpeni towns, the high values obtained from the matrix risks assessment are the result of a great number of hazards to which the towns are exposed and the number of inhabitans that are affected. However, when looking at the total vulnerability assessment, the socio-human potential has a great weight. The human capital (the great number of inhabitants, great number of young people, active population related to total population) cancels the effects that risk manifestation could have, reducing the final results. Through social characteristics, towns are able to adequately respond in case of an emergency situation should appear, so that their vulnerability is lower.

The obtained values offer a general point of view over the community's hazards and socio-human characteristics, which allow a global evaluation of the studied region vulnerability. The final composite map (Fig. 34) and the specific intermediate maps represent elements that can be easily understood and used by the decision factors.

CONCLUSIONS

This paper had more or less bold, but achievable objectives, consisting of the natural and technologic risks assessment, social vulnerability evaluation and the identification of vulnerability reduction methods. One by one, these objectives were disscused in broad chapters, individual or in a wider context, trying to offer efficent and adequate sollutions. Theoretical data coming from previous studies, by renowed authors were used, as well as statistical data and complementary studies, which complete the theme's interdisciplinary and holistic approach. The data were proceesed and adaptated permanently to the proposed theme and the basic concepts, defined at the beginning of the paper (that is „risk" and „vulnerability").

The natural hazard categories were identified in the Arieş river middle basin and then assessed, highlighting the potential risk and the different vulnerability levels. In other words, the causes and the potential consequences which can lead to disasters in the studied region were compared, based on exact data from the specific literature and field researches. Based on these studies, the general conclusion was that despite the existing land use plans and the structural measures reduce the region's vulnerability, and implicitely, the population's, the natural disaster risk (climatic, hydrologic and geomorphologic) is high.

In addition, the technologic risks were identified. These risks are generated by the irrational human intervention in the Arieş river middle basin. It must be mentioned the mining activities, which for decades represented the main pollution and impact source, affecting the environmental factors. Although the mining activities were closed, their environmental and social impact still remains and will be observed in the future, too. In this region a permanent and continous environmental degradation can be seen, despite the technological progresses in vulnerability reduction and disaster prevention. In fact, the conclusions emphasize the fact that the anthropic intervention in the environment increase the risk and vulnerability level of a region.

The social vulnerability level was evaluated by using statistical data, which all pointed to the progressive aging and feminisation of the communities. The main cause is represented by the migration of the young population towards towns, this cause beeing the effect of a primary cause, which is the insufficient incomes. The social vulnerability level is higher, as the aging and feminisation processes are irreversible at the level of the Arieş river middle basin.

The vulnerability reduction methods were given a special consideration, because, as it was already demonstrated in the paper, they exist at theoretical level, but their practical implementation undergoes several defficiencies. Even if there is a training programme comprised in the national legislation, in practice, there is a weak receptivity from the public, demonstrated by the very low volunteer number involved in the intervention actions during an emergency situations. Despite the fact that the potential projects and their access is very easy, the authorities and population lack involvment. Thus, this region never profited from funding supporting its sustainable development and its vulnerability reduction. Solutions which could increase the population's involment to the region's development were proposed. One of these solutions is the regions' tourist potential valorification, currently not exploitated. Therefor, the tourist potential was assesses, from the existing natural and anthropic objectives point of view, as well as from the tourist infrastructure point of view. The declaration of the area as being „under-privileged", with all its resulting consequences is also a mean for socio – economic development.

Considering the studied area realities, with all its geographic, economic and social features, a regional development programme is needed, to addrress the specific necessities and issues. This must integrate the activity sectors, to support the colaboration between the public and the private sector, to assure the proposed activitities coordination and to attract as many funding sources as possible.

Finally, the magnitude and localisation of the natural hazards and anthropic activities were overlapped with the socio – economic potential specific to the local communities, in order to obtain a syntetic and brief presentation, emphasizing those areas which need intervention measures for risk reduction and population protection. The assessment's results were graphically represented in a map, which can be easyly used by the decision maker factors.

As to the author's contributions, these are reflected in the elaboration of a literature synthetis regarding "vulnerability", a relatively new concept in the Romanian literature. The exact and detailed description of the studied area, based on theoretical data from several authors and field studies represents another original contribution. The originality refers also to the identification of those hazards which affect the population in the studied region, followed by the region's vulnerability assessment, as to the identified risks. Such, the region's vulnerability to a series of climatic hazards was assessed, as well as the local communities vulnerability to floods. For assessing the landslied occurence probability, the susceptibility map was elaborated, based on relevant information: slope, lithology, land-use. As to the anthropic activities, the highest risk is that induced by the mining industry. Therefore, the mining risk was assessed using risk matrixes, for each mining exploitation. The paper's original contributions consists in the presentation of the poor demographic situation, presented on a representative map reflecting the demographic reality in the Arieş river middle basin. A special attention was given to the solutions proposed for the area's development. Generally, the viable solutions found can be divided in two categories: access to education and information, supporting the population's preparedness and the economic development, which increases the communities' adaptation and coping capacity. Therefore, those programmes favouring the population's acces to education were presented, as well as those which can attract funding, their practical implementation in the studied region being emphasized. Another original contribution was the region tourist potential assessment, tourism being seen as a viable development strategy and implicitly, a vulnerability reduction method. Finally, a synthetic assessment of the hazards and risks was created, which was graphically represented thorugh a composite map.

This paper tried to create a bridge between the existing risk and vulnerability theories and their implementation in practice. In the same time, the paper represents a useful tool for the decision makers, coming from the public or the private sector, supporting them in making decisions regarding the elaboration and implementation of adequate and necesary measures for risk prevention, in order to reduce vulnerability and protect the population.

It must also be mentioned that without pretending to study the proposed theme in an absolute manner, from the point of view of collected date and disciplinies used, the theme was thouroughly studied, launching in the same time, new research objectives, in the perspective of future studies.

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