“BABEŞ-BOLYAI” UNIVERSITY
CLUJ-NAPOCA
FACULTY OF GEOGRAPHY

PHD THESIS
SUMMARY

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Cluj-Napoca, 2017

"BABEŞ-BOLYAI" UNIVERSITY

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GEOMORPHOLOGICAL AND HYDROLOGICAL HAZARDS AND RISKS IN THE UPPER CRASNA RIVER BASIN

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CHAPTER I
METHODOLOGICAL ASPECTS AND RESEARCH MOTIVATION

1.1. The localization of Crasna Drainage Basin

1.1.1 Mathematical coordinates of the localization of Upper Crasna Basin

Crasna Drainage Basin is situated in the North-Western part of the country and is developed on the territorial units belonging to Sălaj and Satu Mare counties. The mathematical coordinates that define the localization of Upper Crasna Basin are 22° 40” Eastern longitude andi 46° 35” Northern latitude.

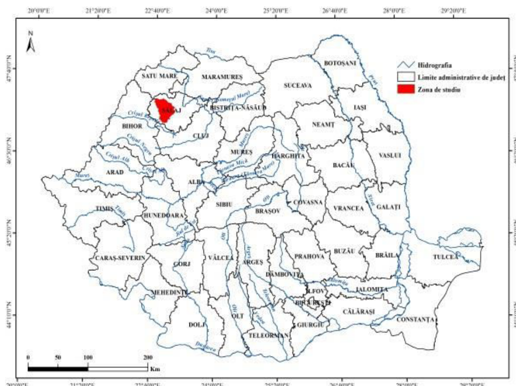
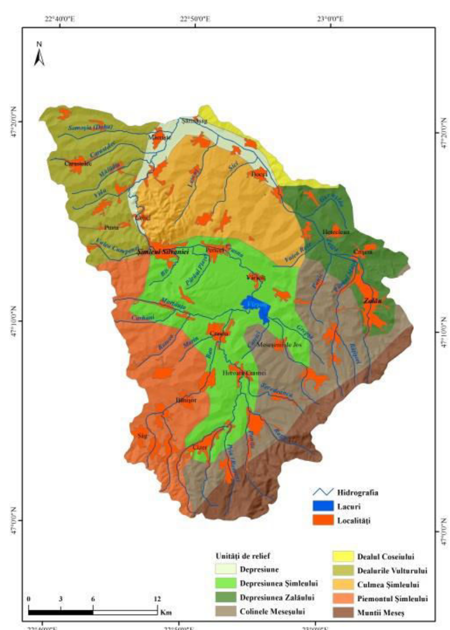


Fig. 1 The localization of research area inside the Romanian territory

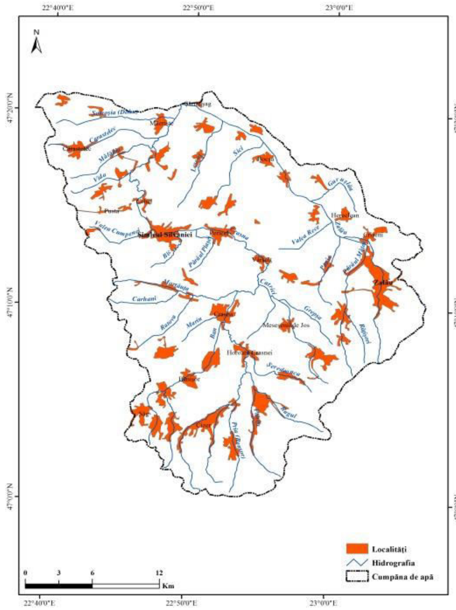


1.1.2 Geographical coordinates of Crasna Basin

1.1.2.1 The elements of the natural setting

Crasna Drainage Basin, until the confluence with Zalău River, includes the following relief units: Meseş Mountains (Western flank), Şimleu Depression, Zalău Depression and the Sylvania (Crasna) Hills with the following subdivisions: Şimleu Piedmont (Bănişor or Bănişor Hills), Meseş Hillocks (Meseşeni – Panic Hills), the crystalline măgurile hillocks of Şimleu and Coşei, Vulturului Hills (Toglaciului Hillocks or

Săcăşeni-Camăr Hills), Şimleu Ridge (Sărmăşag Hills), to which we can add as a distinct subunit, with peculiar features the Crasna corridor.



1.1.2.2 The administrative-territorial units

The Upper Crasna Basin develops only inside Sălaj County, on the territory of fourteen communes (Sâg, Cizer, Bănişor, Horoatu Crasnei, Crasna, Meseşeni de Jos, Vârşolţ, Pericei, Crişeni, Hereclean, Bocşa, Sărmăşag, Măerişte, and Carastelec), one town (Şimleu-Silvaniei) and one municipality (Zalău).

1.2. Short research history of the region

Upper Crasna Basin has been the subject of previous research, at the beginning following a historical trend and being issued monographs, works regarding the toponimy or the geology of the region. The relief of Upper Crasna Basin has been studied regionally on the great relief units. There were also treated problems regarding hydrography, agriculture, vegetation, tourism and settlements.

Recently a series of PhD theses have been issued both at Cluj and Oradea Universities. Crasna Basin is associated with a series of hydrological, geomorphological and human risks dealt with in a series of quite recent works.

1.3. The aim and objectives of the research

The aim of the present research is the assessment of the risks generated by the geomorphological and hydrological processes in the Upper Crasna Basin, setting out their impact on the human communities and the proposal of prevention, mitigation, control and attenuation of their effects.

1.4 Methodological aspects regarding the research of risks and hazards

1.4.1 The evolution of research in the field of hazards and risks

The risk researches have multiplyed lately both on national and international extent: Dauphine, 2001; Cutter, 2001; Dagome, Dars, 2001; Gravley, 2001; Cheval, 2002; Holmes, 2003; Irimuş, I. 1991, 1992, 1997, 2002, 2004, 2005, 2006, 2007, 2010, 2011, 2012, 2013, 2015, 2016, Mac, Petrea 2003, 2004**;** Jones*,* 2001; Grecu, 1997, 2004, 2006; Bogdan*,* 2003; Bălteanu*.* 1993,1997, 2004; Crozier*,* Glade*,* 2005; Alexander*,* 2005, Surdeanu*,* 1998.

On a national extent important researches in the field of natural hazards were done by Coteţ (1978, cited by Florina Grecu, 1997, 2009), Zăvoianu and Dragomirescu (1994, cited by Irimuş, 2006), Bălteanu (2003, 2004, 2010), Grecu (1997, 2009), Surdeanu (2007, 2008), Irimuş (1991, 1992, 1997, 2002, 2004, 2005, 2006, 2007, 2010, 2011, 2012, 2013, 2015, 2016), Sorocovschi (2002, 2004, 2005, 2007, 2008), etc.

An important moment in the research of natural risks and hazards was the last decade of the 20st century called IDNDR – "International Decade for Natural Disaster Reduction".

Later, the principles and objectives of IDNDR were continued by ISDR.

In the last years the research in the field of natural risks and hazards is focused on finding solutions of mitigating the natural risk and growing the level of population resilience following natural disasters.

1.4.2. The definition of hazard, vulnerability, risk

There are multiple **conceptions of risks**. The most common uses are: *risk as hazard*, *risk as probability*, *risk as consequence*, *risk as possible counter effect or threat.*

For the risk to appear there must be a hazard which has a source or a triggering event, a receptor and a way between source and receptor.

Etimolgically speaking, the word hazard comes from the arab word az-zahr meaning dice game, although today the „lotery" meaning is no longer up to date. Hazards are considered „a solution of becoming" underlining their necessity character with a critical role in the self-organisation processes.

DEX (*1984*) "a circumstance or conjuncture (favorable or unfavorable) whose cause remains generally unknown; unpredictable and unexpected happening"

Goţiu, Surdeanu *(2007)* A probable state of a system defined by the possibility of happening with a magnitude that exceeds a generally accepted threshold, with estimated recurrence intervals in a time and space that can not be precisely determined.

Vulnerability can be regarded as a sub function of risk. The term consists in the characteristics of a system which describes its potential of being damaged. It can be described according to all the functional relations between the expected damages and the system's characteristics (susceptibility, the value of the elements exposed to risk) regarding the whole set of relevant hazards induced by the extreme events.

The notion of risk is the object of several interpretations which sometimes show partial or even inadequate senses. We can notice in the first place the frequent use as synonims of the terms « hazard» and « risk ».

The hazards refferes to objects and phenomena, to their actions and characteristics. There are series of unknown facts derrived from the great variability of limit conditions: circumstances of manifestation, especially the moment and place of apparition, the novel or repetitive characterul, breadth, direction, sense and especially the effects they generate (Mac, Petrea 2003)

The concept of risk includes three terms: danger, **vulnerability and exposure**. Each of them is related to the three components of the geographical space: **nature**, man and territory**.**

1.4.3 The classification of hazards and risks

Stângă, 2007, cited by Sorocovschi, 2016, classifies hazards by several criteria:

- Genetic and the type of the agent (endogenous, exogenous and extra-terrestrial)
- Spatial (global-systemic, global with regional effects, local or punctual)
- Temporal (fast, slow)
- Dynamic (which can be forecasted, which cannot be forecasted)
- The type of the probable impact
- The size of the effects (reduced, severe)
- The environment they take place in (atmospheric, marine, continental, inshore)

Risks can be classifyed by several criteria:

1. **The genetic criterion** (natural, human, technological, ecological)

2. **The spatial criterion** (with local, regional, areal or planetary features)

3. **The temporal criterion** (way of manifestation: violent, progressive, slow; duration, the time of the year they appear and take place, rithmicity: daily, seasonal, annual, multiannual; reversibility; frequency: low, moderate, high)

4. The degree of **vulnerability** (low, medium or high vulnerability).

1.4.4 Methods used in the research of hazards and risks

The research of natural hazards and risks is a complex process which needs inter and multi-disciplinary approach in order to serve the aimed purposes. In this respect the correct definition of the phenomena which may have counter effects is a must. Next I have analyzed the causes of the phenomena and the temporal and spatial distribution of the genetic and enhancing factors. On the basis of the historical data I followed the way of manifestation of the processes and their features, realizing graphic syntheses in order to establish common features for a better forecast of the future events. Another action was the calculus of the probability of phenomena with similar features with those that have already taken place.

Very important for the research of risks and hazards is the analysis of the spatial repartition of the generating phenomena and processes. On this basis the risk maps are drawn establishing in the same time the extent a certain territory may be affected in case a certain event takes place.

CHAPTER II

THE PREMISES OF RELIEF MODELATION IN UPPER CRASNA BASIN

2.1 Lithological and tectonic premises

The studied region is the result of the changes at the contact of two major units, Western Carpathians in the South and the Pannonic block in the North, which beginning with the Badenian and continuing with the Sarmatian and Pannonian have suffered strong vertical fragmentation and sinking. So, the evolution of this space is linked to a base made of the crystalline schists of the Pannonic block and crystalline - Mesozoic of Carpathian type or even Palaeogene over which sedimentary formations have been successively submitted.

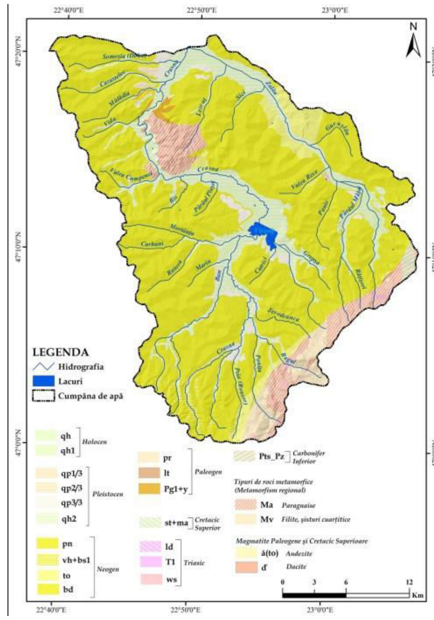


Fig. 4 Geological map of the Upper Crasna Basin (realized according to the Geological Map of Romania, 1960)

2.2 Climatic and hydric premises

2.2.1 The climate

The average annual temperatures vary between 6ºC and 8 ºC in Meseş Mountains, 7 – 8 ºC in Simleu Hillock, and 8 - 9 ºC in Simleu Depression and Crasna hills. The average thermic amplitude is 23ºC (Nicoară, 1998).

The thermic regime of the studied region has been analyzed on the basis of the data obtained from the hydrometric stations (where temperature is also measured) Crasna and Simleu Silvaniei for Crasna Basin and Borla for Zalău Valley, between 2002 – 2012.

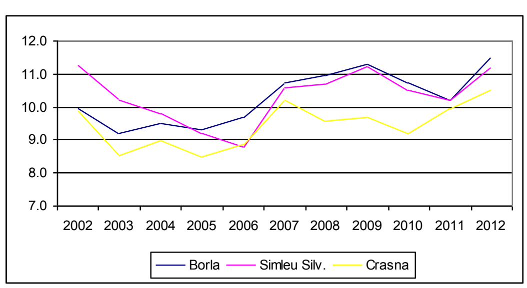


Fig. 5 The average annual temperature in Crasna Basin between 2002 - 2012

Atmospheric precipitations are the main factot that influence drainage and can lead to possible risky phenomena.

The precipitation regime has been analyzed on the basis of the data obtained at Zalau meteorological station and eight representative rainfall stations in Upper Crasna Basin (Borla, Simleu Silvaniei, Crasna, Vârşolţ, Meseşeni, Bănişor, Sărmăşag şi Stârciu) for the period 1990 – 2010.

The region multiannual average, in the analyzed period is of 658 mm/year, the highest values being registered at Bănişor, situated in the Western part of the region (696.78 mm/year), while the lowest are at Vârşolţ, situated in Simleu Depression (601.6 mm/year).

The monthly repartition of precipitations reveals that the rainiest months are June and July, followed by May and September. The driest months are the ones during winter, especially January and February.

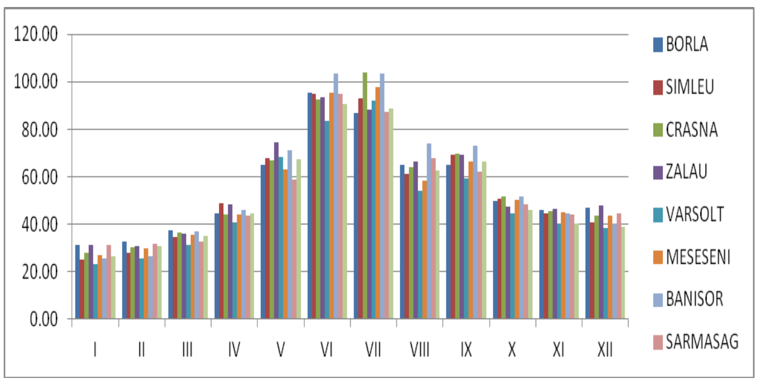
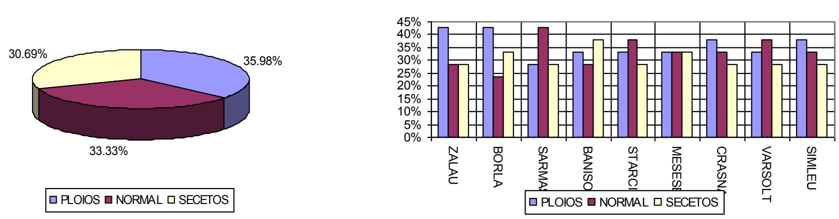


Fig. 6 The monthly repartition of the average precipitation fallen in Crasna Basin between 1990 -2010

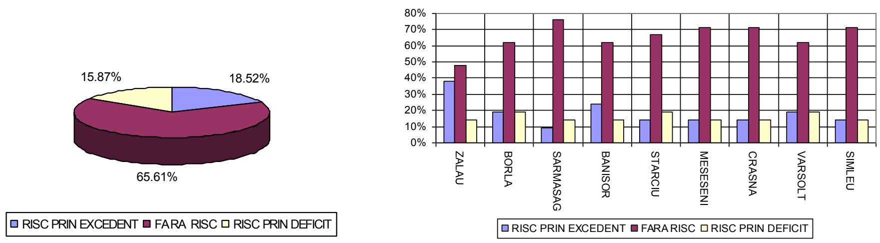
In Upper Crasna Basin, in the research period, there were no extremely rainy or dry years.



a **b**

Fig 7. The average frequency of the years on rainfall domains at the level of Crasna Basin (a) and at the meteorological and rainfall staions (b)

The frequency on groups with or without rainfall risk outlines the share held by the years free of risk against the years with risk by excess or by deficiency.



a **b**

Fig. 8 *The average frequency of the years with or without rainfall risk at the level of Crasna Basin (a) and at the meteorological and rainfall staions (b)*

The snow cover is present over 80 days in the mountains, under 60 days in the lower areas on Crasna and between 60 - 80 days in the rest of the region (Morariu, Sorocovschi, 1972).

2.2.2 Hydrography

The drainage basin, until the confluence with Zalău contains 29 water courses, 21 of them in Crasna Basin, with a total length of 241 km (including Crasna) and 8 in that of Zalău, with a total length of 97 km.

The tributaries are organized dendritically, with an obvious asymmetry rightwards, especially downstream the confluence with Zalăul, its main tributary (S = 274 kmp, L= 37 km), which also spreads its tributary system towards the Western flank of Meseş.

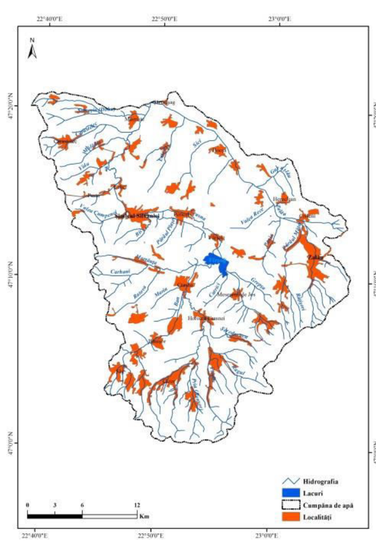


Fig. 9 The hydrographic map of Upper Crasna Basin

The repartition of the drainage during the year shows a monthly and seasonal variation. The maximum monthly volume of the flow is found in June at Crasna (13,64%) and Borla (11,76%) and in March at Simleu Silvaniei (13,54%)

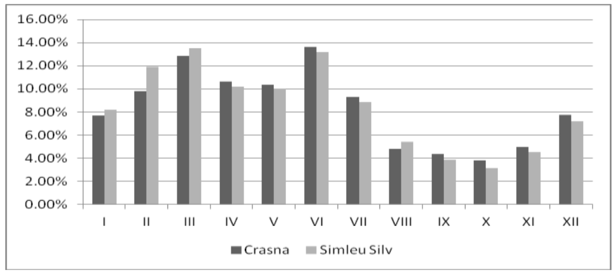


Fig. 10 The repartition of the average monthly flow during the year for Crasna River (1964 – 2010)

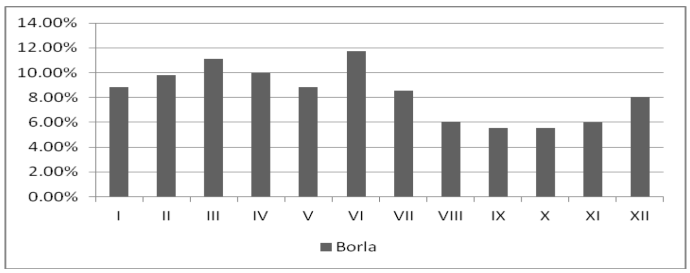


Fig. 11 The repartition of the average monthly flow during the year for Zalău River (1973 – 2010)

The seasonal flow is as follows: spring 29,86% at Borla and 33,88% at Crasna, summer 26,38% at Borla and 27,74% at Crasna, autumn 11,53% at Simleu Silvaniei and 17,07% at Borla, winter 19,91 % at Simleu Silvaniei and 22,90% at Borla. The lowest values of the seasonal flow are registered during autumn because of the low precipitation and the exhaustion of the underground reserves.

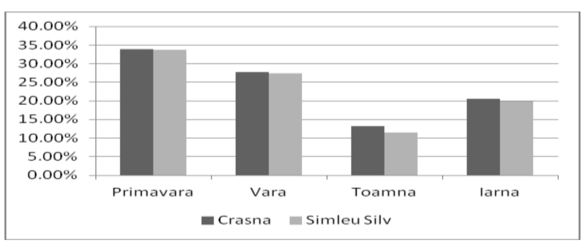


Fig. 12 The shares of the seasonal flow on Crasna River between 1964 – 2010

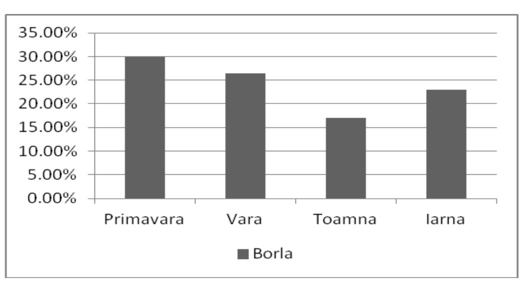


Fig. 13 The shares of the seasonal flow on Zalău River between 1973 – 2010

In order to determine the solid discharge we used the data from Crasna hydrometric station from the period between 1981 – 2009. The multiannual average solid discharge on this period is 3,64 kg/s.

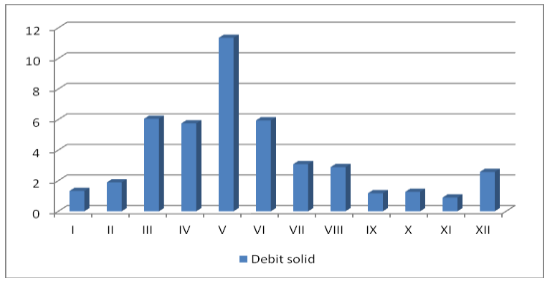


Fig. 14 The monthly repartition of the average solid discharge between 1981 – 2009 at Crasna hydrometric station

2.3 Bio – pedo- geographical premises

2.3.1. Vegetation

The prevailing vegetal association in the montan and hill zone is the forest. The hardwood is characteristic, while the coniferous appear rarely as plantations.

2.3.2 Fauna

The faunistic elements characteristic to the Carpathian Arch (the Carpathian deer, the grouse, the bear, the lynx) are missing or appear very rarely in Meses Mountains. We also meet animals such as the wolf, the boar, the hind, the squirrel, the rabbit, the fox, birds, reptiles, gnavers. Regarding the aquatic fauna we find animals such as the trout, the grayling, the suckerfish, and very rarely the sheatfish (Morariu, Sorocovschi, 1972).

2.3.3 Soils

The physical geographical conditions impose a weak vertical zonation of the main soil types.

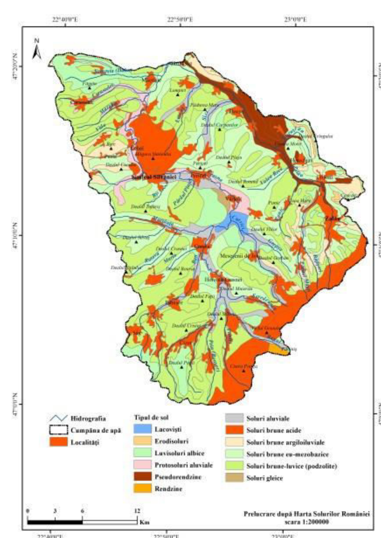


Fig. 15 The map of soils in Upper Crasna Basin

2.4. Anthropic premises

2.4.1. Population density

The population of Crasna basin, upstream the confluence with Zalau, according to the 2011 census, is of 127 421 inhabitants, out of which 80170 live in the urban areas and 47251 in the rural ones (37,09%). The anthropic pression upon the territory is high, the average population density on the whole region being of 158.45 inh/km², much above the national average (93.78% in 2011). Nevertheless the population density has important regional differentiations.

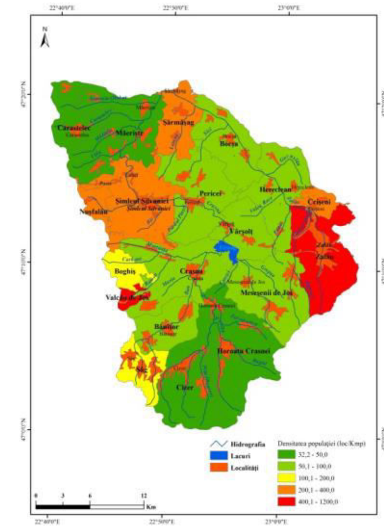


Fig. 16 The map of the population density in Upper Crasna basin

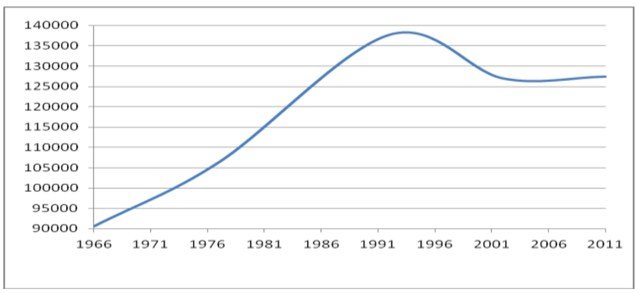


Fig. 17 The evolution of the population in Crasna Basin between 1966 – 2011

2.4.2. Land-use

The Crasna basin shows a great share of the agricultural lands (41,18%) (un-irrigated croplands, prevailing agricultural lands, areas with complex cultures), followed by forests, (21,48%) (hardwood forests and transition areas with bushes) and by those with secondary meadows (19,54%). The built environment (discontinuous urban space, industrial or commercial units, continuous urban space) occupy 9,83% of the research area, while the vineyards and the orchards occupy 7,53%

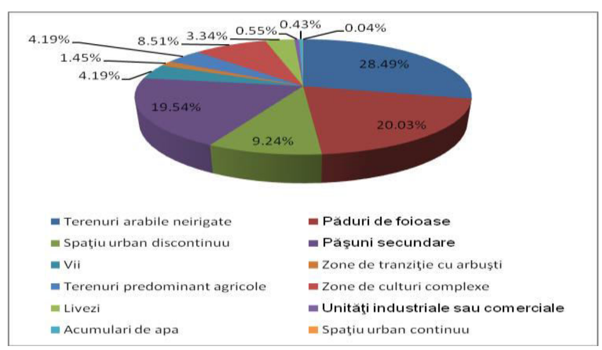


Fig. 18 The shares of different land uses in Upper Crasna Basin

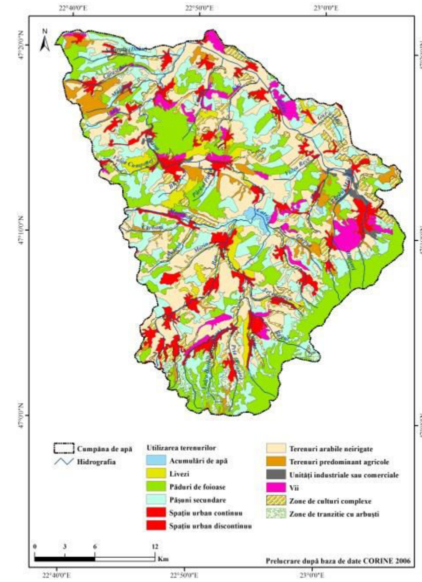


Fig. 19 The map of land use in Upper Crasna Basin (after Corine Landcover 2006)

CHAPTER III.
THE MORPHOMETRY AND MORPHOGRAPYDYNAMICS OF CRASNA DRAINAGE BASIN

3.1 The hypsometry of the Basin

The altitudes in Crasna Upper Basin range between 164 m and 996 m (the maximum is recorded in Pria Hillock peak in Meseş Mountains). Inside this altitude difference have been separated 10 height intervals overlapped over the morphogenetic steps.

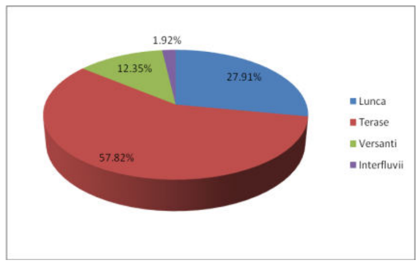


Fig. 20 The share of the morphogenetic steps in Crasna upper basin

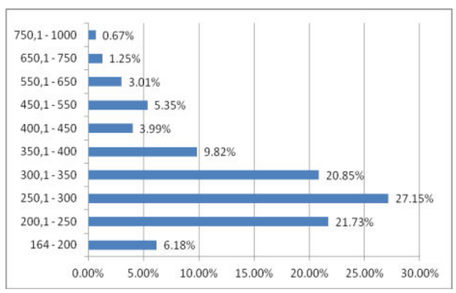


Fig.21 The share of the height intervals in Crasna Upper Basin

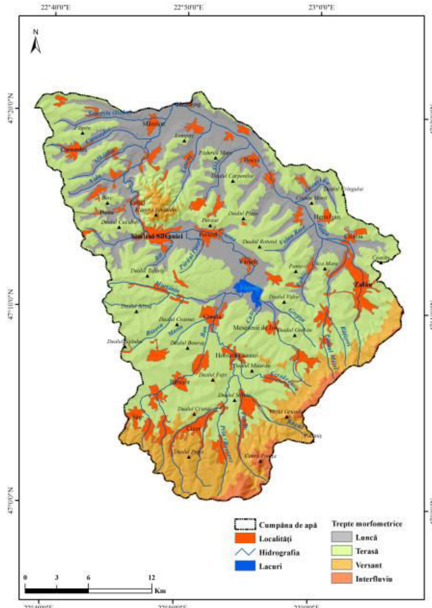


Fig. 22 The map of the morphogenetic steps in Upper Crasna Basin

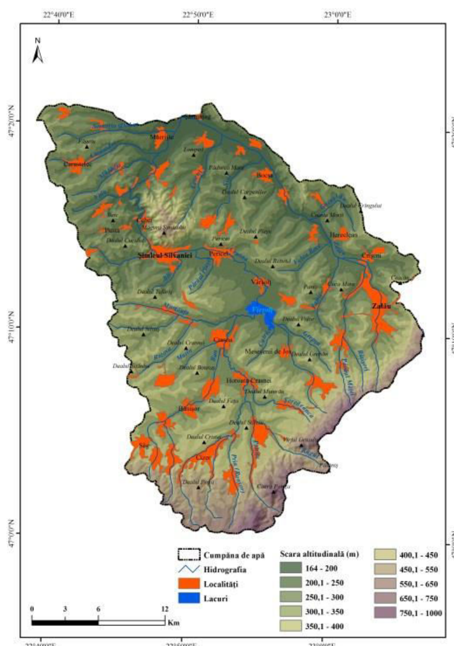


Fig. 23 The map of altitudes in Upper Crasna Basin

3.2 The energy of relief

In Upper Crasna Basin the depth of fragmentation ranges between 2 and 400 m, inside this difference having been established 8 intervals, each of them having different surfaces inside the studied area.

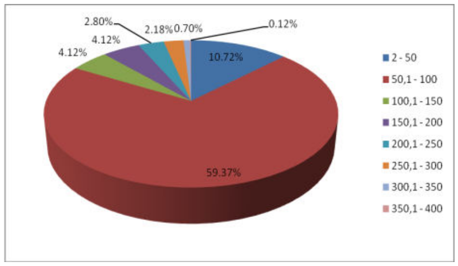


Fig. 24 The share of the different intervals of the depth of fragmentation in Upper Crasna Basin

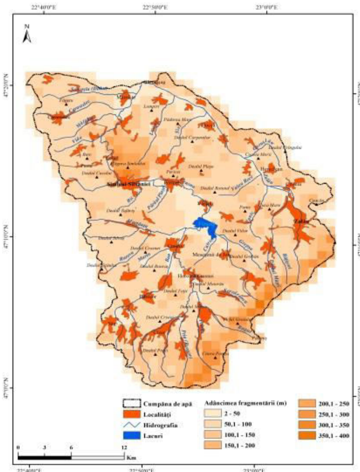


Fig. 25 The map of the depth of fragmentation in Upper Crasna Basin

3.3 The drainage density

Inside Crasna Upper Basin have been separated seven intervals of drainage density, with values between 0 and 4,5 km/sqkm.

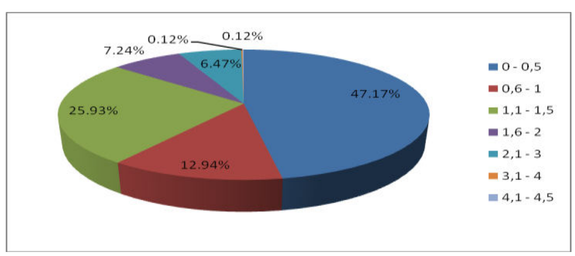


Fig. 26 The share of different drainage density intervals in Upper Crasna Basin

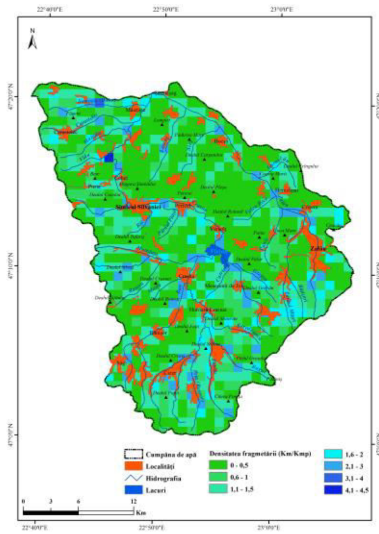


Fig. 27 The map of drainage density in Upper Crasna Basin

3.4 Slope declivity

There have been separated six classes of slope declivity with values between 0 and over 35° in Crasna Upper Basin, until the confluence with its main affluent, Zalau.

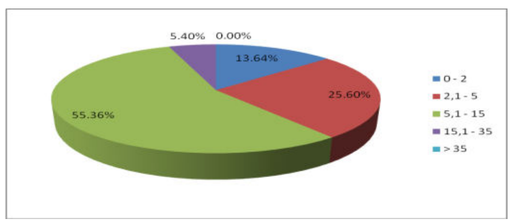


Fig. 28 The share of the surfaces with different slope declivities in Upper Crasna Basin

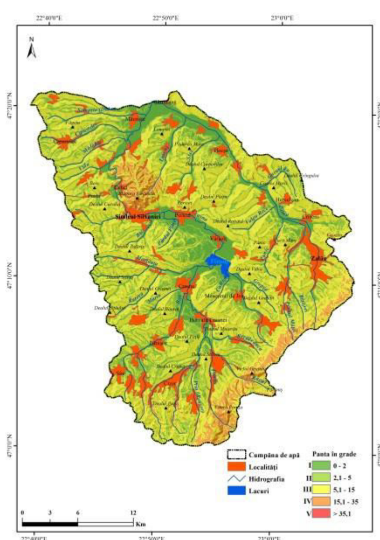


Fig. 29 The map of slope declivity in Upper Crasna Basin

3.5 Slope orientation

In Upper Crasna Basin, except the plain surfaces which have a small share (3,97%), the other types of orientations occupy quite equal surfaces.

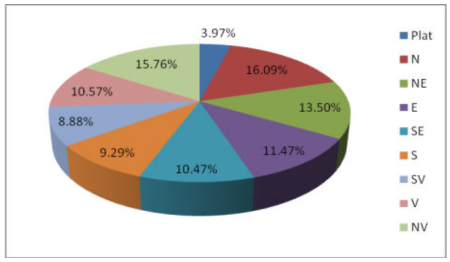


Fig. 30 The share of the surfaces with various surfaces in Upper Crasna Basin

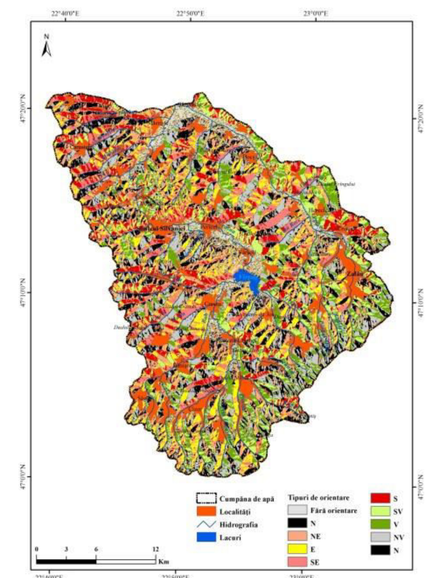


Fig. 31 The map of slope orientation in Upper Crasna Basin

CHAPTER IV
HAZARDS AND RISKS ASSOCIATED TO THE GEOMORPHOLOGICAL PROCESSES

4.1. Definition and classification of geomorphological hazards

Geomorphological hazards take place at the level of the terrestrial surface (including the underwater one), their triggering depending especially on the geomorphological conjuncture, even if the triggering factor (the determinant agent) may be of a different origin (more often meteorological or anthropic) (Goțiu).

Fl. Grecu, 2006 classified the geomorphological hazards as follows:

- Slope processes (gravitational processes, hydric slope processes)
- Channel processes (channel erosion, bank erosion)

4.2 Landslides

4.2.1 The definition and classification of landslides

"Processes of shaping of slopes, under the action of the gravity, which take place on a separation surface, between the mobile and fixed part (sliding surface, sliding plan, friction mirror)" (Surdeanu, 1998)

The classification of landslides (after Surdeanu, 1998):

- Age (old, new)
- The determined morphology (lenticular, in steps and furrows, with monticules and waves, sliding valleys, with complex micro morphology)
- The type of the movement and the way of propagation (translational, rotational)

4.2.2 The causes of landslides

Regarding the relief energy, on the greatest part of the research area (90.07%) it does not exceed 150 m, fact that does not favor the mass movements. The drainage density also has low values on the greatest part of the research area (86.04% of the territory has drainage density under 1.5 km/kmp), which does not create favorable conditions for the triggering and development of landslides. Things change in the case of slope declivity. Surdeanu notices that slopes between 6 - 17º "dominate the mass movements of the land-slide type". Crasna Basin presents extremely favorable conditions from this point of view, over half of its surface fitting this declivity interval (55.36%). Regarding slope orientation, those with Northern and North-Eastern orientation are considered the most proper for landslides. In Crasna Basin the slopes with Northern orientation occupy 16,09%, while those with North- Eastern orientation occupy 13,50% of the surface.

Regarding lithology we notice that 44.75% of the surface is proper for the development of landslides.

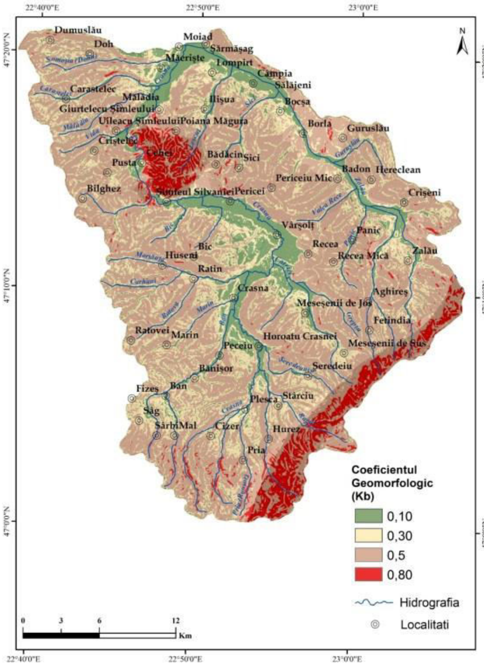
The climate, especially precipitations substantially contribute to the triggering and dynamic maintaining of landslides. From the calculus of ASPP results that 35.98% of the analyzed years were excedentary from the pluviometric point of view. Also 30.69% of the analyzed seasons could be characterized as rainy. Taking into consideration the Angot index, we notice a number of 966 months with over-unity values, indicating a rain excess. One third of the maximum precipitation in 24 hours (30.79%) had values exceeding 20 mm. we also have to mention that there were registered a series of extraordinary values (over 50 mm).

Vegetation. Nowadays in Upper Crasna Basin forests occupy only 20.03% of the whole surface. The risk is greater as there was massive afforestation, the place of the old forests having been taken by agricultural land or buildings. So we can also discuss about anthropic causes such as afforestation and occupying the surfaces with inadequate cultures for the type of deposit or the position on the slope. We can also add road building and various human activities which can lead to the triggering of landslides (malfunctions of water pipes which determine soil over wetting, exploitation of clay in carriers – the case of the landslides on Dealul Ortelecului, in Zalău).

4.2.3 The susceptibility to landslides in Upper Crasna Basin

The map of natural risk to landslides has been drawn using an integrated informational system, (GIS), according to the present legislation (H.G. 447/2003). The maps representing the risk coefficients were drawn (lithological coefficient, geomorphological coefficient, structural coefficient, hydro-climatic coefficient, hydro-geological coefficient, seismic coefficient, forest coefficient anthropic coefficient).

Fig 32. The map of the distribution of the lithological coefficient (ka)



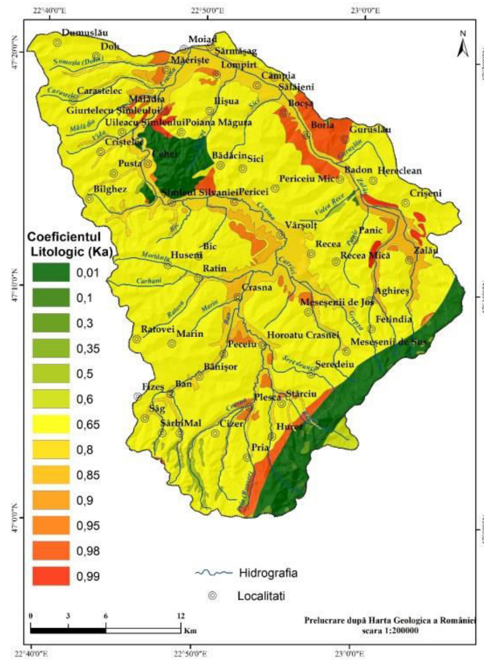
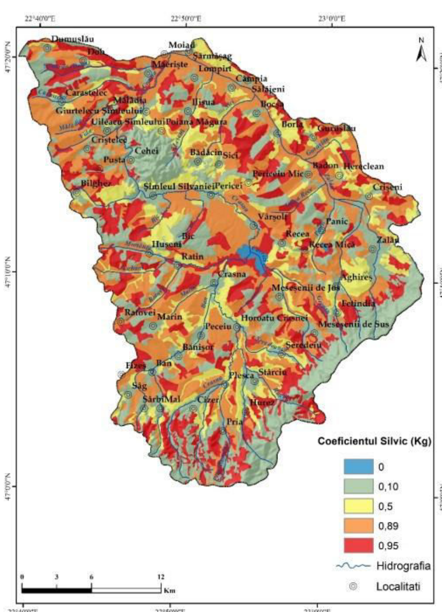


Fig. 33 The map of the distribution of the geomorphological coefficient

Fig. 34 The map of the distribution of the forest coefficient



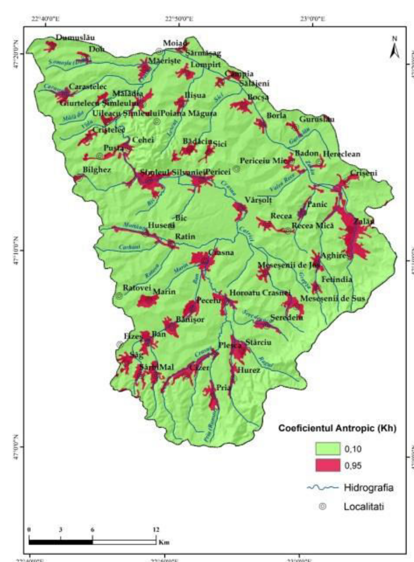


Fig. 35 The map of the distribution of the anthropic coefficient

Analyzing the coefficients, using ArcGis 10.2, we determined the hazard coefficient according to the formula:

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

K(a) – lithologic coefficient

K(b) – geomorphological coefficient

K(c) – structural coefficient

K(d) – hydro-climatic coefficient

K(e) – hydrogeologic coefficient

K(f) – seismic coefficient

K(g) – forest coefficient

K(h) – anthropic coefficient

The average hazard coefficient has values between 0,0003 and 0,4092.

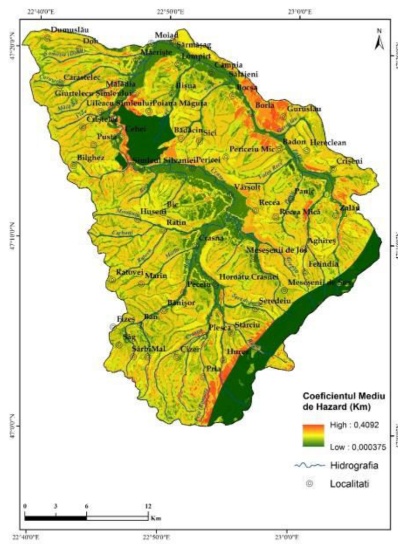


Fig 36 The map ofthe distribution of the average hazard coefficient

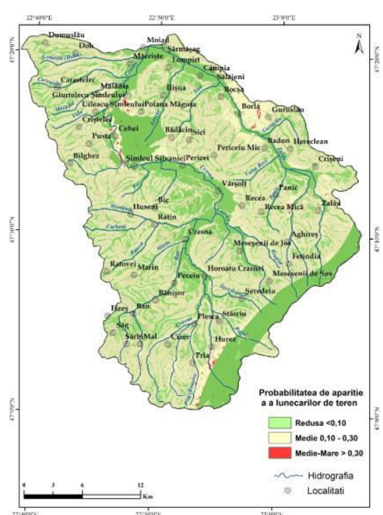


Fig. 37 The map of the probability of landslide issuing in Crasna Upper Basin

Reffering to the surfaces occupyed by each probability class 64.34% of the basin has a medium susceptibility of lanslides issuing while only 0.24% shows a medium-high susceptibility.

In order to test the succes rate of the model the area of the landslides was compared with the identifyed probability classes. We can notice a very good validation of the medium probability class (59 % of the identified landslides belonging to this class), while the low probability class contains 33 % of the existing landslides. .

The analysis is considered to be successful taking into consideration the fact that less than 25% of the area affected by landslides is outside the greatest susceptibility class, according to the recommendations of Carrara, 1988.

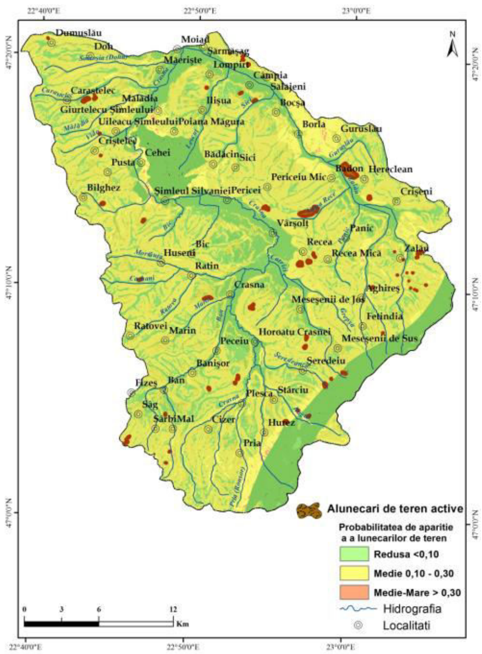


Fig. 38 The map of active landslides in Upper Crasna Basin

4.2.4 Active landslides in Crasna Basin – case studies

In the research area there were identifyed 314 active landslides.

Landslides in Ortelec (Zalău municipality)

The North-Western slope of Ortelec Hill in Porolissum neighbourhood, upstream the Tunari clay pit, has been identifyed as an area with landslides. The first phenomena were registered in 1969-1970, while severe landslides appeared in the years 1970, 1975, 1998, 2000, 2006 periods with heavy rainfall. In July – August, a new landslide became active and extended until the limit of the pit.

Fig. 39 Landslides in Zalau municipality (Ortelec)

The landslides in Sărmăşag

The phenomenon begun 30 years ago, evolving slowly but continuosly. It affected households, agricultural land and utility networks situated on the slope with Southern orientation in Sărmăşag. There have been identifyed 161 households situated on Teilor, Viilor, Sălajului, Rândunelelor, Pomilor and Liliacului streets which presented fissures, cracks, horizontal and vertical shifings. The landslides also affected 290 ha of agricultural land.

The landslides in Recea, Vârşolț commune

In Recea, Vârşolț commune, the hillock on the left side of DC102, has been identified with landslides manifestations. The phenomenon became active between 1992 – 1993 when the first forms of slope instability manifested. A number of 13 households have been damaged. The houses show major structural damages, some of then needed to be displaced.

Fig. 40 Lanslides in Recea

The landslides on the right bank of Crasna Valley, Recea-Pericei area

The affected area is situated on the right bank of Crasna, downstream Vârşolţ Reservoir, on the territory of Vârşolţ and Pericei communes. Aproximatively 630 ha are strongly affected by errosion and landslides. As a consequence of landslides the communal road DC103 (Pericei - Sici) and the national road DN 1 H Oradea – Zalău were affected on 1,5 km, respectively 1,8 km.

4.3 Soil errosion

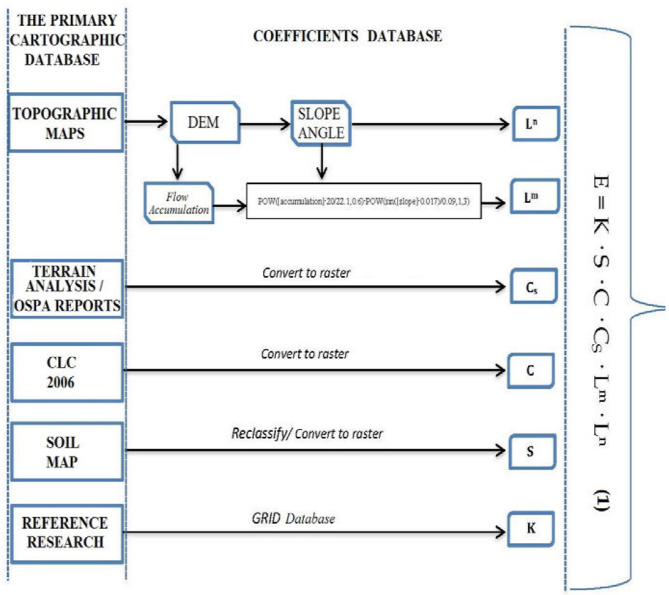
4.3.1. General models for estimating soil errosion

The ROMSEM model (Romanian Soil Erosion Model) was created by using an empiric model and it is based on the equation created by Moțoc M. et al in 1973, revised in

1979 and reconfirmed in 2002. It is based on the universal relation used by the Soil Conservation Service in USA, taking into consideration the climatic conditions in Romania.

4.3.2. Database and methodology

The applying scheme of the model, with the description of the steps done for obtaining the necessary coefficients for the construction of the database is presented in the following figure.



where,

E – average annual erosion (t/ha/year)
K – the erosivity coefficient established on the basis of the climatic erosivity
S – the correction coefficient for soil erodability
C – the correction coefficient for the management factor of the coverage and the characteristics of vegetation i
Cs – the correction coefficientul for the effect of the anti-erosional works
Lm – the length of slopes (m)
În – slope declivity (%)

Fig. 41 The steps of the application of the model for determining the soil erosion (Roşca, S. 2014)

4.3.2.1 Rain erosivity

The rain erosivity coefficient calculated on the basis of rain (climatic) agressivity, for Crasna Basin, has a value of 0,067.

4.3.2.2 Soil erodability

The values of the used factors were estblished taking into consideration the Romanian pedo-climatic characteristics and have values between 0,8 and 1,1

4.3.2.3 The correction coefficient for the effect of cultures

The vegetal protection factor is included in this model because of the anti-erosional role played by vegetation. The used values were between 0 şi 1.

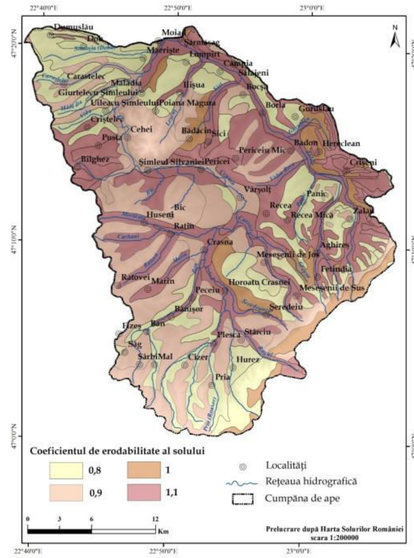


Fig.42 The map of the distribution of soil erodability coefficient

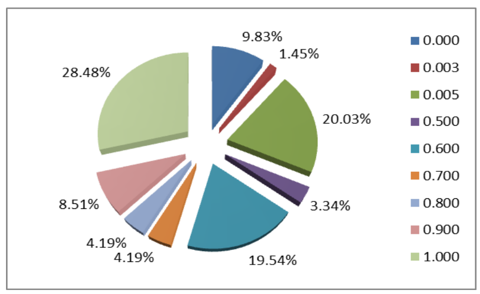


Fig. 43 The areas occupyed by various cultures and the corresponding correction coefficients for their effects

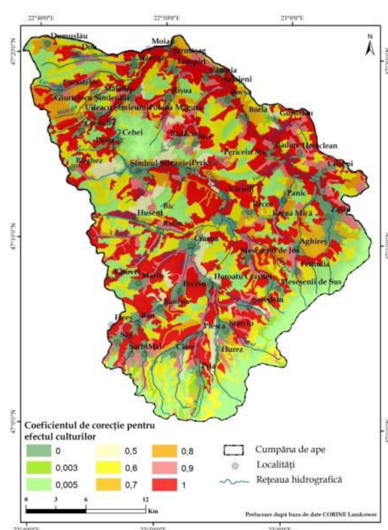


Fig. 44 The map of the distribution of the correction coefficient for the effect of cultures

4.3.2.4 The correction coefficient for the effect of anti-erosional works

Although the benefits of the anti-erosional works are well-known, there are very few of them in the research area, so the correction coefficient for the effect of anti-erosional works was given the value 1, in order not to influence the final result of the modelling.

4.3.2.5 The topographic factor

This topographic indicatot takes into consideration the lenght of the slopes and the declivity. The highest values are recorded in the higher areas in Meseş and Plopiş Mountains and in Simleului Hillock, while the lowest in the river meadows of the main water courses, Crasna and Zalău.

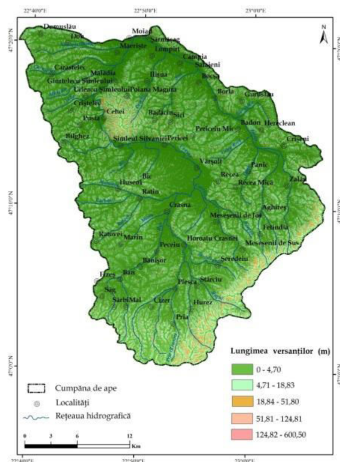


Fig. 45 The map of the distribution of the topographical factor – slope length

4.3.3 Results

Having the entire database converted in raster format, helped by the Raster Calculator function in the Spatial Analyst module, the value of the potential soil erosion was calculated, using the formula:

$$E= K * S * C * C_S * L^m * L^n$$

Where,

E – average annual erosion (t/ha/year)

K – the erosivity coefficient established on the basis of the climatic erosivity

S – the correction coefficient for soil erodability

C – the correction coefficient for the management factor of the coverage and the characteristics of vegetation

Cs – the correction coefficientul for the effect of the anti-erosional works

Lm – the length of slopes (m)

În – slope declivity (%)

In Upper Crasna Basin we obtained values of the annual erosion between 0 and 23,18 t/ha/year. There were defined six value classes, with different shares within the basin.

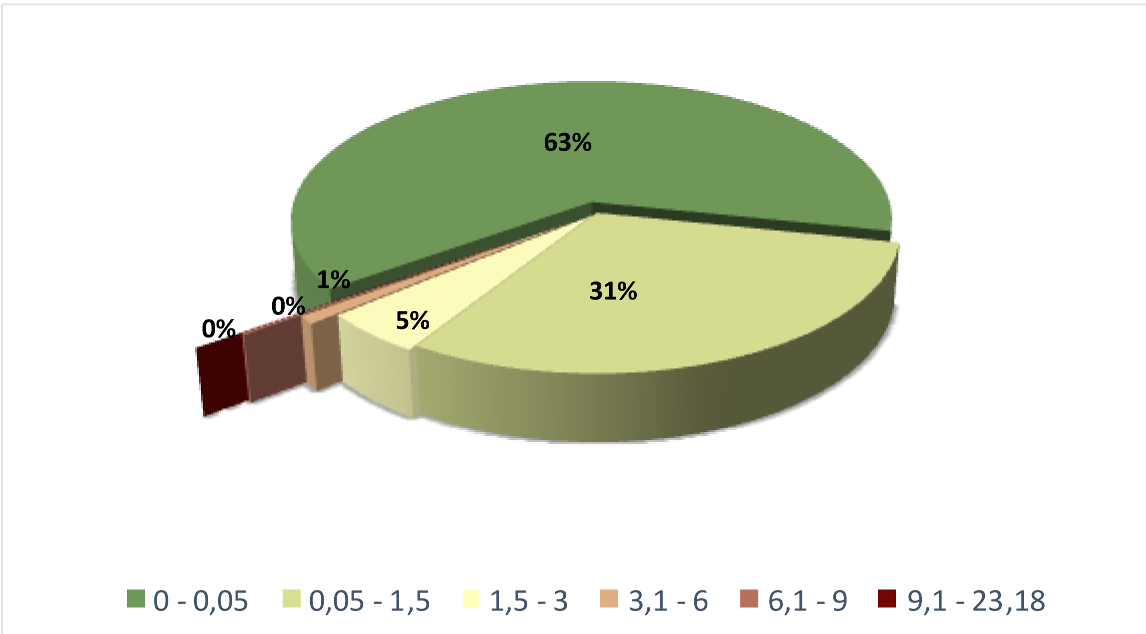


Fig. 46 The shares of the erosion classes in Upper Crasna Basin

The territorial repartition of the soil erosion values calculated by means of USLE model is shown in figure no.

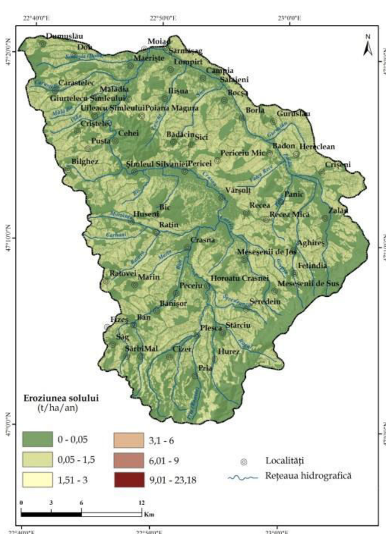


Fig. 47 The map of the distribution of average soil erosion after applying the USLE model

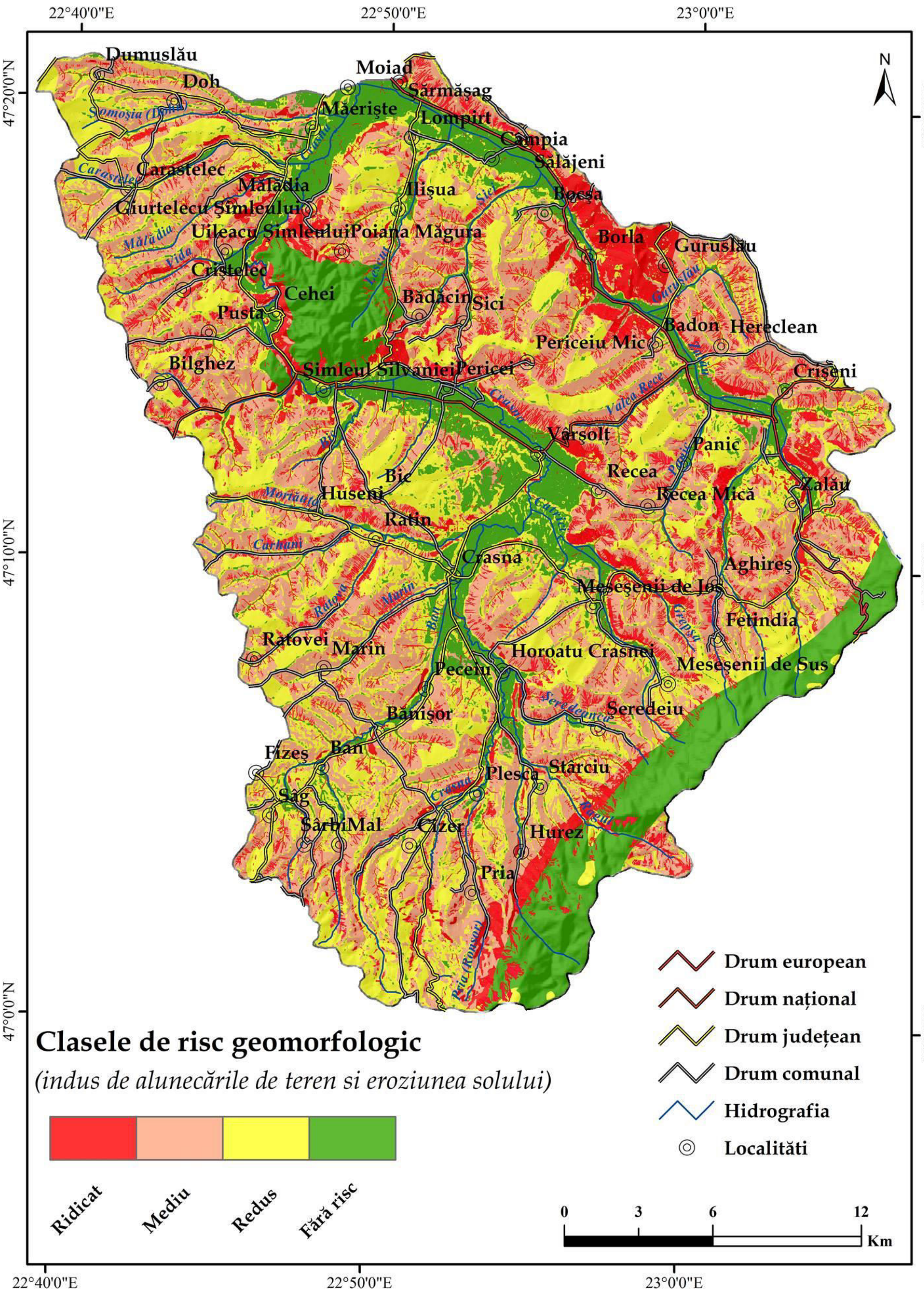


Fig. 48 The map of the geomorphological risk (landslides and soil erosion)

4.4 The silting of Vârşolţ Reservoir

The silting process of Vârşolţ reservoir has been monitorised beginning with the year 1983 and following with successive hydro-topometric surveys done in 1983, 1985, 1989, 1991, 1995, 1997, 2002, 2009

The determination of the sediment volume reaching the reservoir was done by means of the solid discharge measured at Crasna hydrometric station (the only station on Crasna River in Sălaj county where the solid discharge is being measured) between 1981-2009.

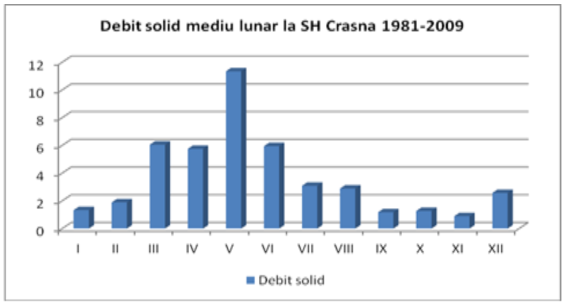


Fig. 49 The monthly variation of the solid discharge at Crasna station between 1981 – 2009

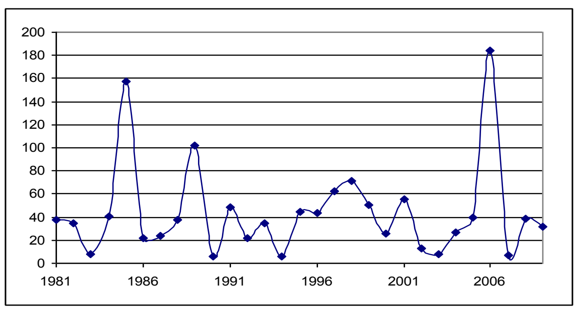


Fig. 50 The annual variation of the solid discharge at Crasna station between 1981 – 2009

Table 1

The evolution of the chracteristic volumes of Vârşolţ reservoir between 1979-2009 (mil. m³) (source Someş-Tisa Water Branch)

Year	**1979**	**1983**	**1985**	**1989**	**1991**	**1995**	**1997**	**2002**	**2009**
DEAD V.	0.592	0.279	0.183	0.117	0.084	0.081	0.048	0.0005	0.000
AVAILABLE V.	20.908	18.371	17.877	16.783	16.687	16.449	16.358	16.0695	15.7886
FLASH FLOOD PROTECTION V.	11.900	11.224	11.220	10.840	11.138	10.460	10.367	10.460	8.6233
ABOVE OVERFLOW V.	14.400	14.626	14.400	12.955	13.041	12.870	12.874	12.858	15.5364
FLASH FLOOD ATTENUATION V.	26.300	25.850	25.620	23.795	23.879	23.330	23.241	23.318	24.1597
GLOBAL V.	47.800	44.500	43.680	40.695	39.650	39.860	39.647	39.388	39.9483

The global volume has been silted in an extent of 15% between 1979-1991 and of 16,4 % on the entire period. The silting degree of the global volume on the entire period is shown in figure 50. (Moigrădean, 2013)

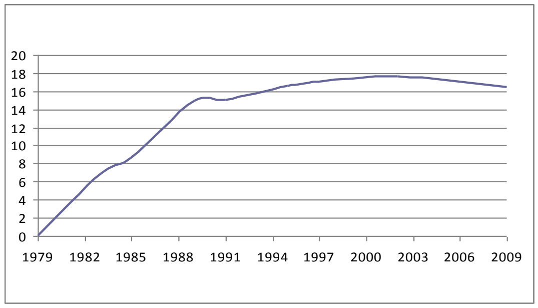


Fig. 51 The silting degree of the global volume of Vârşolţ reservoir between 1979 – 2009

The silting rhythm varies along the 30 years of functioning of the reservoir, being more intense in the first years and reducing in the last years.

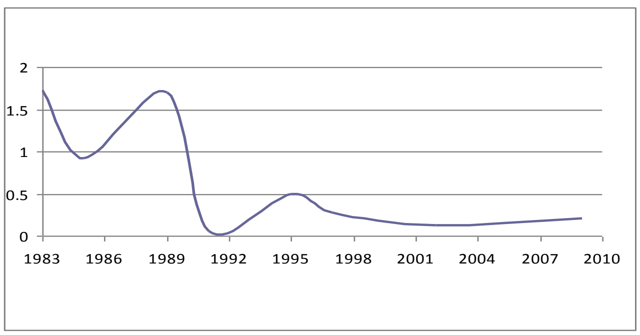


Fig. 52 The evolution of the annual silting rate of Vârşolţ reservoir between 1979 – 2009

Between 1979 -2009 5.71 mil mc of sediments accumulated in the reservoir resulting to a silting degree of 26.5%. The annual average silting rate is relatively low (0,59%). (Moigrădean, 2013)

We calculated a silting time of 252 years, which means an acceptable span towards the characteristics of the reservoir's catchment area.

CHAPTER V

HAZARDS AND RISK ASSOCIATED WITH HYDROLOGICAL PROCESSES

5.1. The classification of hydrological hazards

5.1.1. Uni criterion classification of hydrological hazards

It takes into consideration several criteria: spatial criterion, temporal criterion, the way of manifestation of phenomena and processes, the nature of phenomena and processes, the impact of phenomena and processes, the perception of hydrological phenomena and processes, the forecasting and prevention of hydrological phenomena and processes.

5.1.2. The multi criteria classification of hydrological hazards

The spatial criterion is the most important for geographers, reason why in defining the major hazard types it was taken into consideration the environment where the hydrological processes and phenomena take place.

Hydrological hazards in the continental domain

- Extreme hydrological hazards
- Hydrodynamic processes and phenomena
- Stationary hydrological processes and phenomena
- Hydrological interferrence processes
- Frost and defrost processes
- Silting
- Erosion

Hydrological hazards in the marine and oceanic domain

5.2 High floods

5.2.1 Definition and classification of high floods

High floods are specific to the maximum flow regime and are characterised by a sudden and short duration increase of the levels and discharges of the rivers, usually over the commmon values, followed by the decrease of waters slower than the increase.

High floods are classified according to several criteria: genesis, the shape of the hydrograph, the climatic zone they take place, magnitude and issuing probability, returning period, way of manifestation, the nature of the induced effects, etc.

5.2.2 Triggering factors of high floods

5.2.2.1. Atmospheric precipitation

Out of the analisis of the frequency on value classes of WASP resulted the fact that in the research period lacked the extremely rainy years. The average frequency on the region of the very rainy years is low (3,17 %) the average frequency of the moderate rainy years (15,34 %) is lower than that of the little rainy years (17,46 %).

The frequency on groups with or without rain risk shows the fact that the share of the years free of risk is higher than that of the years with risk by rain excess or deficiency

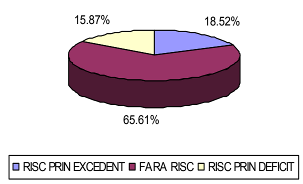


Fig 53. The average frequency of the years with or without rain risk at the level of the whole region

The values of WASP have also been calculated for the hot (April – September) and cold (October – March) seasons.

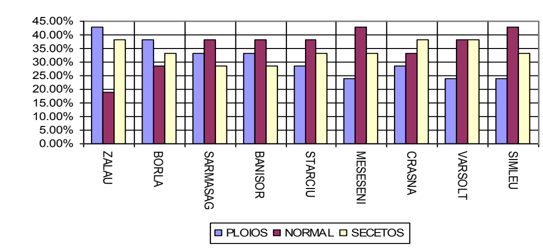


Fig. 54 The average frequency of the hot semesters on rain domains in Upper Crasna Basin

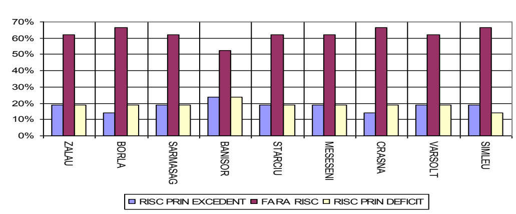


Fig.55 The average frequency of the hot semesters with or without rain risk in Upper Crasna Basin

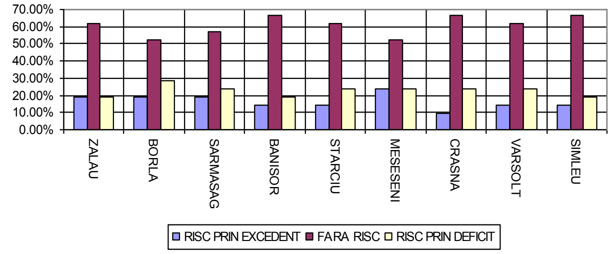


Fig. 56. The average frequency of the cold semesters with or without rain risk in Upper Crasna Basin

In order to outline the rain excess or deficiency at an annual and seasonal level we used WASP while for showing these elements at a monthly level we used the Angot rain index. The subunitary monthly values show a dry month while overunitary values happen in case of rainy months (these have a rain risk by excess).

Precipitations are directly correlated with discharges. The maximum precipitation in 24 hours are extremely important.

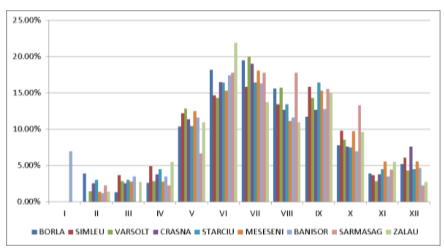


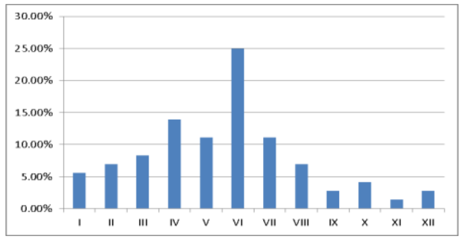
Fig. 57 The monthly frequency of maximum precipitation over 20 mm in 24 hours in Upper Crasna Basin between 1990 – 2010

5.2.2.2. The snow layer

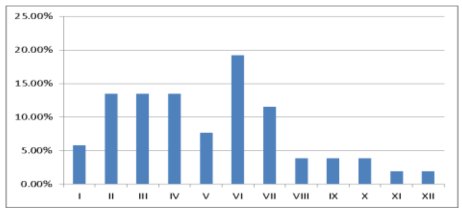
Analyzing the thickness of the snow layer on the basis of the data obtained at nine rainfall stations in Crasna Basin between 1993 -2010, we notice an average thickness of 2 centimeters at all the stations taken into research. Regarding the monthly repartition of the snow layer thickness the highest values are recorded in January and February (4 cm multiannual average), while the lowest values are in April and November, when the snow appears very rarely.

5.2.3 The frequency of high floods

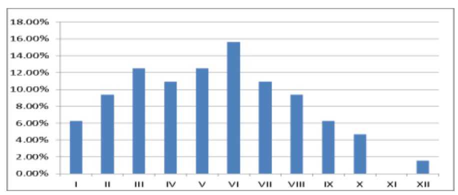
In order to analyze the high floods in Crasna Basin we took into consideration their monthly, seasonal and semestrial frequency. Regarding the monthly frequency of normal high floods we notice that it is maximum in June al all hydrometric stations (Moigrădean, Sorocovschi, 2015).



a. Crasna



b. Simleu Silvaniei



c. Borla

Fig. 58. The monthly frequency of high floods in Upper Crasna Basin.

5.2.3.2. The seasonal frequency of high floods

The study of the seasonal frequency was done both for the normal and important high floods.

Regarding the seasonal frequency of normal high floods the highest values are recorded during the summer, followed by spring and winter, the lowest values being recorded during the autumn.

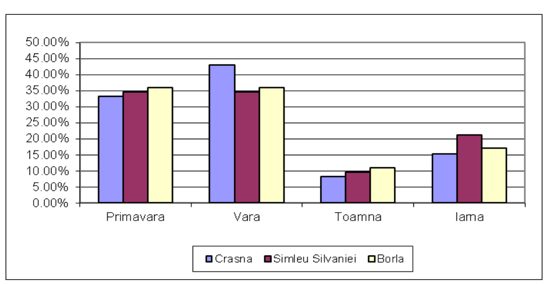


Fig. 59. The seasonal frequency of normal high floods in Upper Crasna Basin

Important high floods. As for the normal high floods the highest frequencies are recorded during the summer, over half of them (52.11%), taking place in the hot season. The highest percentage is recorded at Crasna (55.88%), followed by Simleu Silvaniei (50%) and Borla (48.48%).

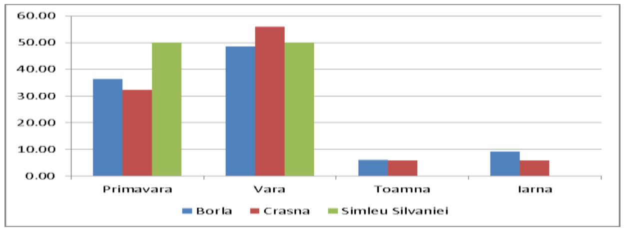


Fig. 60. The seasonal frequency of important high floods in Upper Crasna Basin

5.2.3.3. The frequency of high floods on genetic types

Considering the time span from May to November as representative for the manifetation of pluvial high floods and December – April for the mixt ones, we can notice a balanced repartiton of the high floods of pluvial and mixed origin in the researched basin.

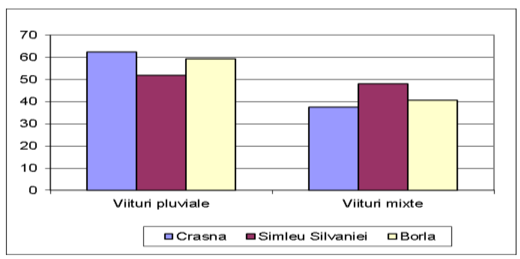


Fig. 61. The shares of the genetic types of high floods in Upper Crasna Basin

5.2.4. The analysis of the parameters of high floods in Upper Crasna Basin

5.2.4.1. The duration of high floods

Analising the data from the three hydrometric stations in the basin (Crasna and Simleu Silvaniei – on Crasna River and Borla on Zalău) regarding the total duration of high floods resulted the fact that the highest frequency belong to those with a total duration of over 96 hours, with a share of 78.19%, while the high floods of 0 - 24 hours have a share of 0.53 %.

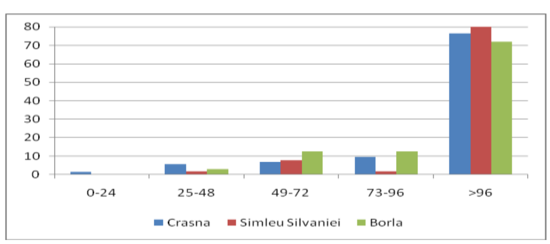


Fig. 62. The total duration of high floods in Crasna Basin (expressed in % of the whole)

The increasing duration is defined as the time span between the beginning of the high flood and the moment it reaches the maximum discharge. We can notice that almost half of the recorded high floods (49.47%) have an increasing time of over 48 hours. Follows the group with 25 - 48 hours (28.19%), the lowest frequency belonging to the high floods with an increasing time of under 6 hours (only 2.13%).

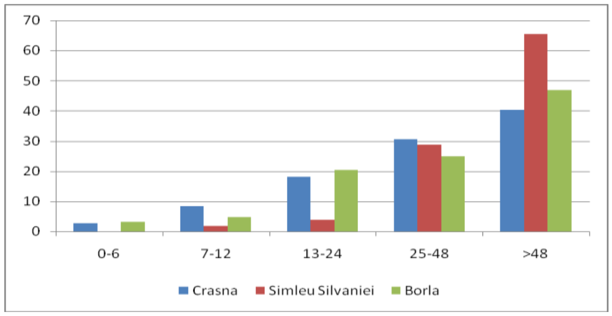


Fig. 63 The increasing duration of high floods in Crasna Upper Basin (expressed in % of the whole)

5.2.4.2. Maximun discharges

The maximum discharge is reached the moment the increasing duration is over. The highest maximum discharges reached at the hydrometric stations in the researched basin, for the period 1974 - 2010, vary between 143 m^3/s (discharge recorded during the high flood between the 30st of August and 3rd of September 1989 at Borla hydrometric station) and 224 m^3/s (at Crasna station on Crasna river, during the high flood between the 23rd of July and 2nd of August 2010).

5.2.4.3 Maximum levels

Regarding the maximum levels they had average values between 325,73 cm at Crasna hydrometric station and 375,98 cm at Simleul Silvaniei station.

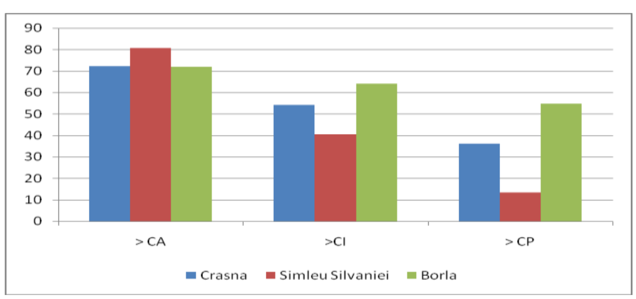


Fig. 64 The high floods (%) that exceeded the defense levels in Upper Crasna Basin between 1974-2010

5.2.4.4 The volume of high floods

There werw high flood volumes with average values between 2,456 mil. m^3 at Borla and 7,529 mil. m^3 at Simleu Silvaniei, the parameter growing together with the increasing of the surface of the drainage (Moigrădean, Sorocovschi, 2015).

5.2.4.5.The drained water layer

For Crasna Basin were recorded average values of this parameter between 14,84 mm at Borla and 21,22 mm at Crasna (Moigrădean, Sorocovschi, 2015).

5.2.4.6 The shape coefficient

For the shape coefficient we obtained values between 0,16 (for the high floods at Crasna station Crasna) and 0,40 (for those at Simleu Silvaniei).

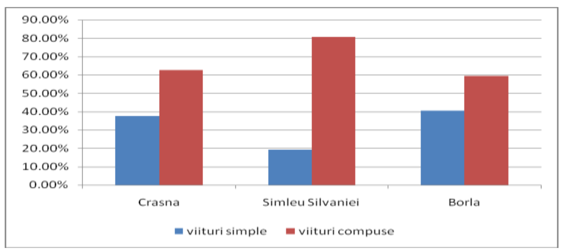


Fig. 65. The share of the simple and compound hydrographs in Crasna Upper Basin

5.2.5. Case studies

In order to exemplify the triggering factors and the parameters of the high floods I have chosen the greatest high flood recorded at each station in the basin, in the research period:

- The high flood between 23 July – 2 August 2010, Crasna, on Crasna River
- The high flood between 19 – 31 July 1974, Simleu Silvaniei, Crasna River
- The high flood between 30 August – 3 September 1989, Borla, Zalău River

5.2.5.1 The triggering factors of high floods

Taking into consideration that the three high floods happened in the hot season, they are pluvial high floods, the triggering factor being the abundant rainfall**.**

5.2.5.2. Evolution and parameters of high floods

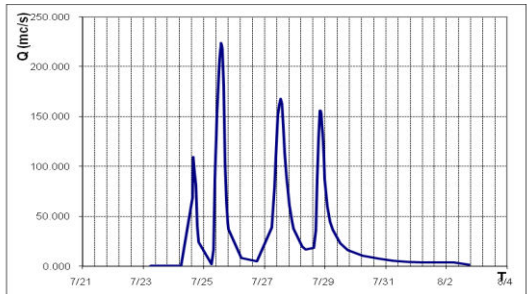


Fig. 66 The hydrograph of the hifh flood between 23 July – 2 august 2010, Crasna, Crasna River

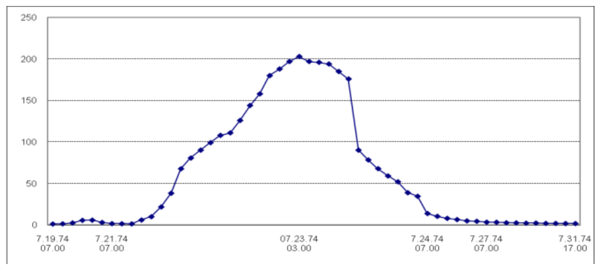


Fig. 67 The hydrograph of the hifh flood between 19 - 31 July 1974, Simleu Silvaniei, Crasna River

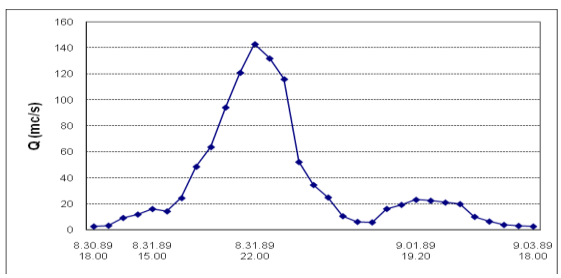


Fig. 68 The hydrograph of the hifh flood between 30 August – 3 September 1989, Borla, Zalău river

5.3. Floods

5.3.1 Definition of the term

From a physical point of view, a flood on a river is a more intense water flow over the natural or artificial banks of a river. The full channel level is only one of the levels or trasholds that my be considered critical for certain purposes (J.A.A Jones, 1997).

5.3.2 Classification of floods

According to the determinant factors: natural and accidental floods.

The spatial criterion: fluvial (on rivers), littoral (in the seaside areas) and urban.

According to the extent of the affected surface: punctual, local and regional (seaside floods, the floods on the large rivers).

According the way of manifestation the natural floods may be classified as: slow, fast and torrential.

Acoording to genesis there are several types of natural floods: pluvial, nival, mixed, caused by the growing of the level of underground waters, by landslides, etc.

According to frequency, the dimension and the total damages: small, large, exceptional an catastrophic.

5.3.3. Determinatives in flood issuing

Liquid precipitations are the main factor that determine the apparition and intensification of floods in Upper Crasna Basin.

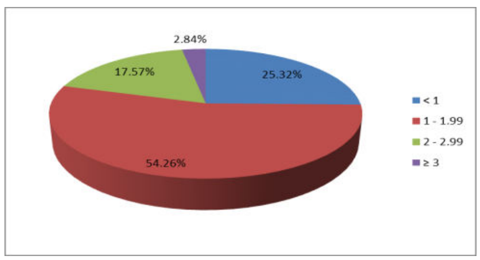


Fig. 69 The values of Angot index in the periods with floods in Upper Crasna Basin between 1995-2010

We also took into consideration the maximum rainfall in 24 hours in the month of flood issuing, which is a determinative for flood issuing. There were exceptional cases, with values over 60 or even over 70 mm of rain fallen in 24 hours.

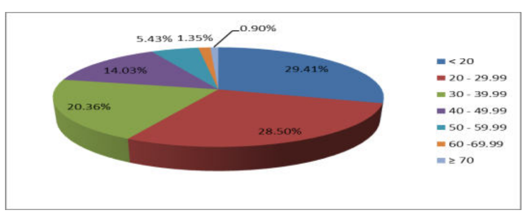


Fig. 70 The maximun rainfall in 24 hours in the periods with floods in Upper Crasna Basin

5.3.4. Intensification conditions

Crasna Basin, until the confluence with its main tributary, Zalau, has a surface of 890 sqkm, being a middle-size drainage.

The shape of the drainage is another important flood intensification factor.

Considering the lithologic structure, 86,21% of the substrate can be considered permeable, 5,74% with medium permeability and 8,05% impermeable substrate.

The average drainage density in Crasna basin is of 0,41 km/km², value that indicates a very low fragmentation.

From the source until the confluence with Zalău, Crasna river has a length of 71 km.

Over half of the analyzed surface has medium slopes, with values between 5-15°.

Regarding the anthropic intensification conditions we mention in the first place the presence of the built surfaces which prevent the infiltration of water, growing in this way the quantity of flown water.

5.3.5 Flood parameters

A. Spatial parameters

The law of waters no. 107/1996 defines the flooded area as the land surface of the major river bed, delimited by a level of the water mirror corresponding to certain discharges in situations of high waters".

The flooded area for Upper Crasna Basin was delimited on the basis of the "Maps with the marking of the potential flooded areas in Crasna Basin", maps elaborated for SGA Sălaj, presenting the flooding limit for discharges with the insurance of 1%.

We can notice o greater extension of the flooded area in Zalau drainage than in that of Crasna, fact determined by the moderatin role of the Vârşolț reservoir.

B. Temporal parameters

Regarding the monthly frequency of floods we can notice their predominance in June and July, each of them having a share of 18,96% of the whole. With close value is May (17,24%), while the lowest frequency is in November, when no flood took place. Low frequencies are recorded in January (1,13%) and February (2.86%).

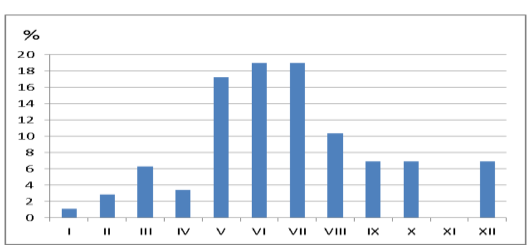


Fig. 71 The monthly frequency of floods in Upper Crasna Basin between 1974-2010

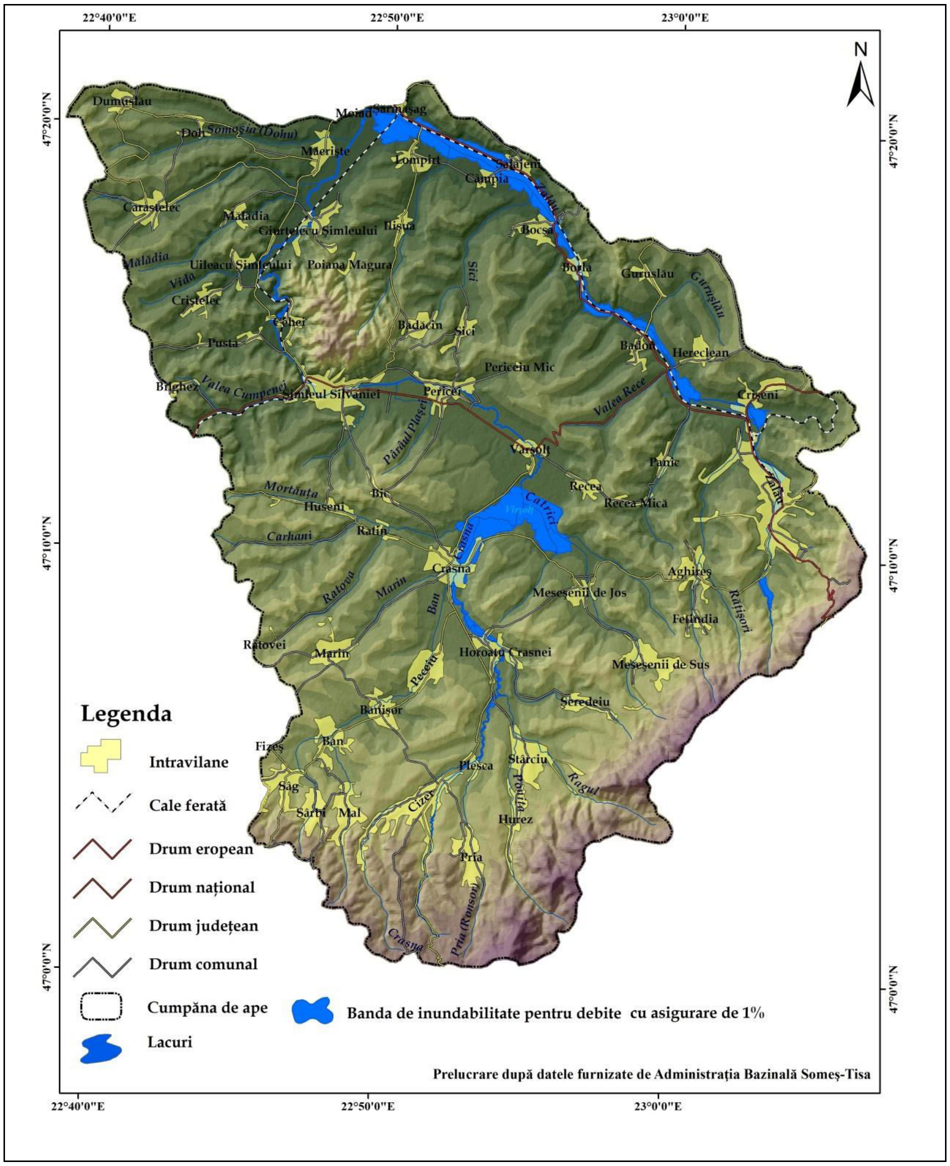


Fig. 72 The map of the distribution of the flood stripes for discharges with insurance of 1% in Upper Crasna Basin

Althoug in the greatest extent floods are peovoked by high floods, there are differences regarding the monthly frequency of the high floods and the floods in the analized period.

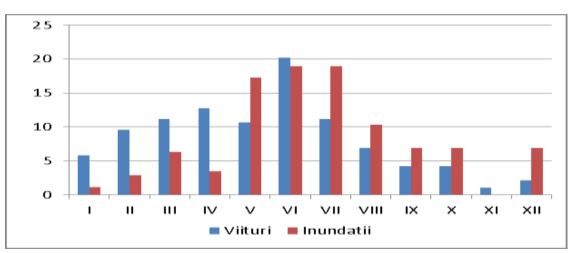


Fig. 73 The monthly frequency of high floods vs the monthy frequency of floods in Upper Crasna Basin between 1974 – 2010

The seasonal frequency shows their predominance in summer when almost half of the studied cases recorded (48,26%). Over a quarter (26,99%) of the cases recorded in spring, the fewest having been recorded in winter (10,88%) and autumn (13,78%).

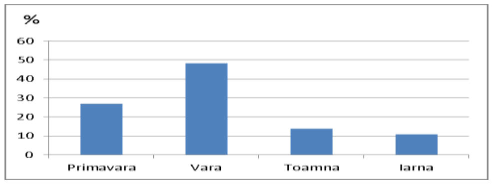


Fig. 74 The seasonal frequency of floods in Upper Crasna Basin between 1974 – 2010

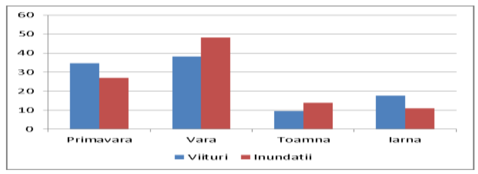


Fig. 75 The seasonal frequency of high floods vs the seasonal frequency of floods in Upper Crasna Basin between 1974 – 2010

The average duration of the floods recorded in Upper Crasna Basin between 1974-2010 is of 11,33 days.

The identification of the returning periods of the maximum discharges was possible as of consequence of the sistematic recording of the discharges. The highest frequency appears for the discharges with a returning period between 5 and 10 years. The lowest frequency is encountered for the discharges with a returning period of 100 years or longer, such a discharge being recorded only at Simleu Silvaniei in 1974. Regarding floods, the most discharges have a returning period of under 5 years.

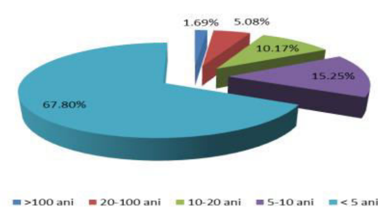


Fig. 76 The frequency of the floods in Upper Crasna Basin with different returning periods

C. Quantitative parameters

The highest average volumes recorded at Crasna hydrometric station (12.27 mc), followed by Simleul Silvaniei (10.73 mc) and Borla (6.84 mc).

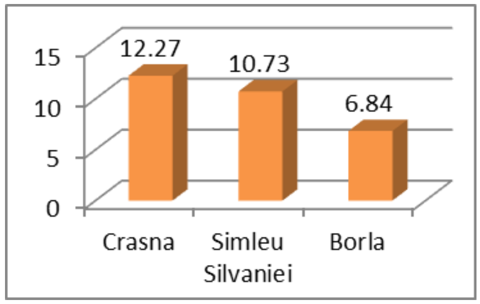


Fig. 77 The average volumes recorded at the hydrometric stations in Crasna Basin at the floods between 1974-2010

5.3.6 The repartition of floods in Upper Crasna Basin

High floods are the main triggering factor of floods, in Crasna Basin, on the research area. Not all the high foods lead to the flooding of the nearby surfaces, but only those which exceed a certain level, namely the flooding level and especially the danger level.

According to the records of Someş-Tisa water Branch, in the analised period (1974 – 2010), in Upper Crasna Basin, both on the main course and on the tributaries, there were signaled 29 floods which also provoked damages. They happened in 15 years of the 37 of the period, being recorded one to three periods with floods per year.

5.3.7 The effects and damages produced by floods

The effects of floods are multiple and complex, affecting various domains of human life and activity as weel as the environment. According to this the effects of floods can be classified in social, economic and ecologic effects.

Regarding the social effects there were no human lives losses or severe injuries. Following the flood in August 2005 sanitary effects were recorded determined by the affecting of some local water sources (fountains), which diminished the possibilities of watter suply of some rural settlements situaded on the water courses of Crasna (Crasna – 20 fountains) and Zalău (Crişeni - 35).

An important problem related to the ecological effects of floods is that of bank erosion.

Regarding the erosion on the two main rivers in the basin we can notice the prevalence of the phenomenon on Crasna River, where almost three quarters of the events (72,73%) were recorded as compared to only 27,27% on Zalău.

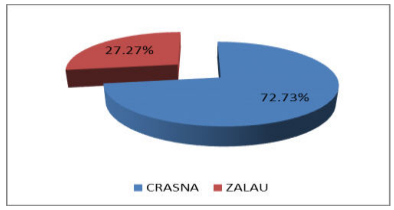


Fig. 78 The repartition of bank erosion on drainages in Upper Crasna Basin

Regarding the periods when the phenomenon took place we can notice its dominance towards the end of the analized period.

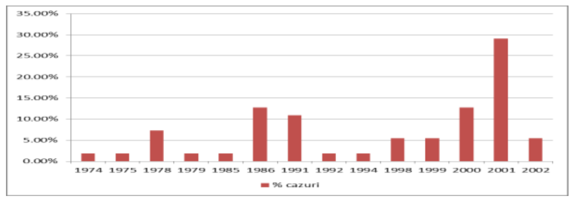


Fig. 79 The annual frequency of bank erosion in Upper Crasna Basin

As for the intensity of erosion we can notice the dominance of the class with high intensity (53,42%), followed by the medium class(31,45%). In 15,13% of the cases the recorded erosion was very high.

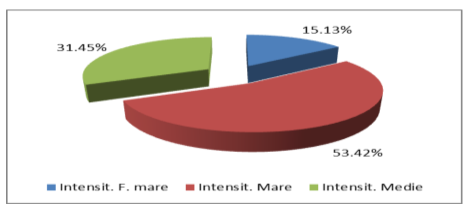


Fig. 80 The intensity of bank erosion in Upper Crasna Basin

The tangible economic damages produced by floods in Upper Crasna Basin

All the 14 communes and two towns in the basin have been affected by floods during the 29 events recorded in the research period. The floods affected households, social-economical objective, agricultural land, ways of communications, bridges and footbridges, sewerage, electricity and telephony networks and also hydraulic works done on the water courses. In the 15 years when floods were recorded, all the communes in the researced area were affected, in different extents. The most affected (number of cases) was Crasna, where recorded 19 flood episodes.

The years with the most important floods (which affected the most settlements in the basin were 1974 and 1998, in each of them being affected 15 of the 16 settlements in the researched area.

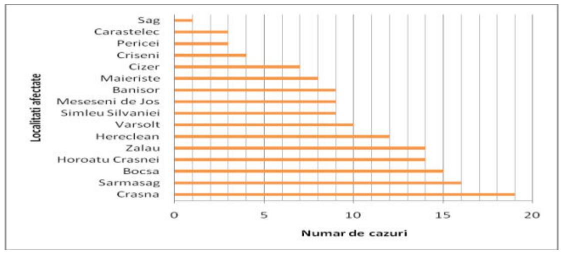


Fig. 81 The number of floods recorded in Upper Crasna Basin between 1974 – 2010

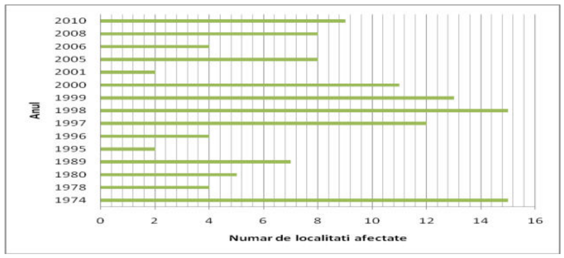


Fig. 82 The number of settlements affected by floods in Upper Crasna Basin between 1974 - 2010

Table 2

The damages produced by floods in Upper Crasna Basin between 1974 – 2010

Affected objective	Dimension of damage
Households (houses and annexes)	1823
Social-economical objectives	31
Agricultural land	25 362.5 ha
County road	18.4 km
Communal road	122.85 km
Forest road	34.2 km
Railways	0.4 km
Streets	30,8 km; 5.75 kmp
Alleys	30.95 km
Bridges	91
Footbridges	50
Sewerage networks	24.987 km
Gutters	3.83 km
Electricity lines	0.4 km
Electricity poles	8
Telephony lines	0.1 km
Bank defence works	1748 ml
Bottom thresholds	33
Bank erosion	4020 ml
Concrete walls	170 ml
Hydraulic works	30 km
Water course regularisation	4.58 km
River bed degradation	1 km

5.3.8 Regionalisation of flood risk

5.3.8.1 The elements exposed to risk

If we look at the map of the settlements we notice that the most are situaded on the water courses, main of tributaries. Another element exposed to risk in Crasna basin is the ways of communication. The 14 communes (Sag, Bănişor, Cizer, Horoatu Crasnei, Meseşeni de Jos, Crasna, Vârşolț, Pericei, Carastelec, Măierişte – in Crasna Basin, Crişeni, Hereclean, Bocşa, Sărmăşag – in Zalău Basin), Simleu Silvaniei and Zalău, house according to the 2011 census, 127 421 inhabitants, 62,91% in the urban environment and 37,09% in the rural one. The average population density is high, 158.45 inh/km², over the national average, of course with many refional differences.

5.3.8.2 The flood risk map

Out of the total surface of the research area (804.04 kmp), only 25.49 km, representing 3,17%, are inside the flooding strip with 1% insurance. This surface faces various degress of risk.

The greatest surface (64% of the flooding strip and 2.04% of the surface of the basin) belongs to the medium risk class. The high risk class holds 8% of the surface of the flooding strip with 1% insurance and 0.24% of the surface of the research area, while the very high risk class holds 10% of the flooding strip and 0.32% of the surface of the basin. The rest of the surface of the flooding strip has a low flooding risk.

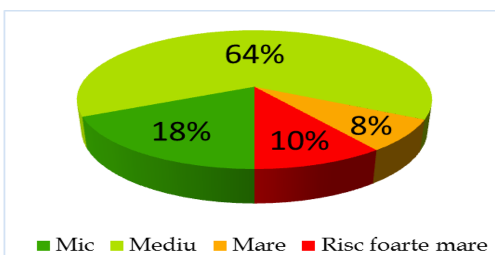


Fig. 83 The shares held by surfaces with different degrees of risk inside the flooding strip in Upper Crasna Basin

The largest extension of the area exposed to risk is encountered on the territory of Crasna, where the maximum width of the flooding area is over 1 km (1080 m). The situation is different in Zalău drainage, where the extension of the flooding area is much larger. The maximum width (1003 m) is found on the territory of Sălăjeni (Bocşa commune).

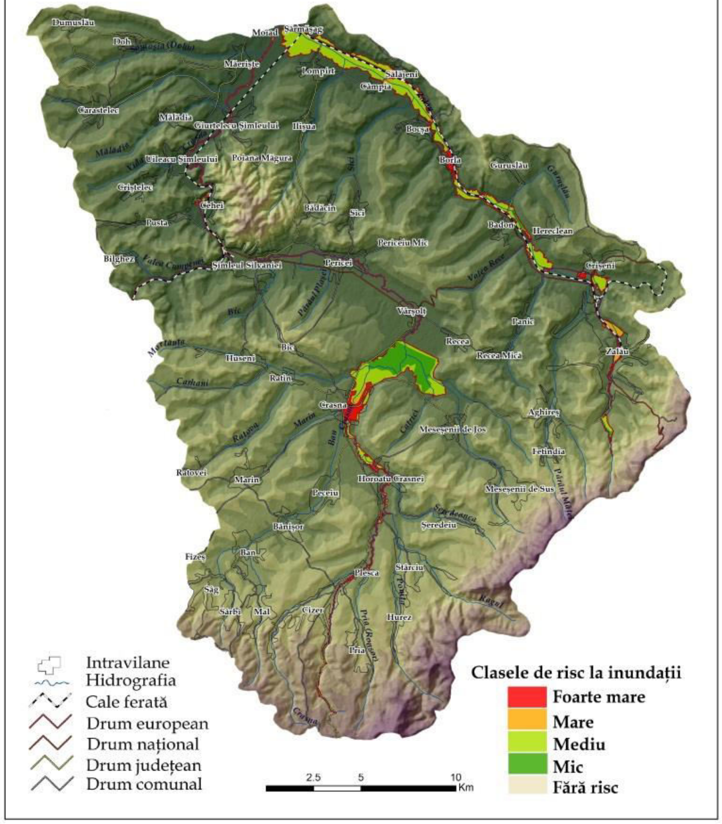


Fig. 84 The flood risk map in Upper Crasna Basin

CHAPTER VI

PREVENTION, MITIGATION AND CONTROL MEASURES OF RISKS INDUCED BY GEOMORPHOLOGICAL AND HYDROLOGICAL PROCESSES

6.1 The Romanian legislative framework of the management of emergencies issued by geomorphological and hydrological phenomena

The functioning and the attributions of the committees and operative centers of emergencies, created for diminishing the negative effects of the emergencies are regulated by HG 1491/09.09.2004 şi OUG 21/2004.

The committees for emergencies are:

1. The National committee for Emergencies
2. The ministerial committees for emergencies
3. Bucharest committee for emergencies
4. The county committees for emergencies
5. The local committees for emergencies

The operative centers for emergencies may be with permanent or temporary activity, the latter being constituted at the level of the local administration.

6.2 The management of the emergencies induced by the geomorphological processes in Upper Crasna Basin

6.2.1 Landslide prevention and control measures

HG 447/2003 regulates the necessity and proposes the methodology for realising the natural risk maps to landslides.

Regarding the prevention of the landslide potential, the actions that may be taken must be targeted towards preventing the water reach the clay layer.

The measures of stopping an existing landslide are mainly targeted towards two directions:

- Works done in order to stop the water reach and accumulate into the landslide area
- Works done to collect and evacuate the water out the area affected by landslides

6.2.2 Prevention, control and mitigation measures of the negative effects of landslides in Upper Crasna Basin

The landslides in Ortelec, Zalău municipality

Specialty studies and proper works for this phenomenon were done (drains, maintenance and consolidation on certain areas indicated by the studies).

It was decided and implemented the closing of the pit situated nearby the affected houses.

In order to prevent severe human and material prejudices it was decided that Zalau Town Hall should take action for a terrain exchange. So the citizens have to handle to the Local Council the terrain under the damaged houses and be given instead a parcel of maximum 500 sqm where to build a new house.

The landslides in Sărmăşag

Taken measures:

Taking into consideration that the evolution of the will severely affect the existing households, the folowing were considered as a must:

1. Expertising the whole slope in order to establish the causes that led to landslides and the technical solutions to ensure the stability of the slope;
2. Based on the conclusions of the technical expertise the tecnical project will be written in order to execute the necessary works, proposed by the expertise;
3. Identification of the financing sources for the execution of the works in the shortest time possible.

Landslides and soil erosion on the right bank of Crasna, Recea-Perice area

Specific land reclamation works were proposed to be executed, as folows:

A. Prevention of surface soil erosion - 2030 ha
B. Preventin of landslides - 180 ha
C. Prevention of deep erosion - 0,7 km

Landslide in Recea, Vârşolț commune

Because the phenomenon took place in the autumn, the coming of the cold season imposed, on short term, the execution of some minimal repairing works in order to insure decent housing.

At that moment there was no permanent solution for stabilizing the slope and making the buildings safe, so a technical expertise was begun in order to find a solution in this respect.

6.3. The management of the emergencies induced by the hydrological processes in Upper Crasna Basin

6.3.1 Flood prevention and control measures

Structural measures represent the changes of the environment in order to directly diminish the damages, including dams, levees, protection walls, land waves and changing the design of the buildings.

Semi-structural measures are a secondary form of response to dangers**.**

Non-structural measures mainly refer to: applying a proper management of the flooded ares, the existence of a prompt and efficient action plan in the event of a flood, the exact forecasting and warning in the event of a flooding and also the evacuation of the population from the areas prone to flooding, the assesment of the resistence of the buildings in the areas that may be flooded (Sorocovschi, 2002).

6.3.2 Prevention, control and mitigation measures of the negative effects of floods in Upper Crasna Basin

In Crasna Basin, upstream the confluence with Zalău, have been realized three types of hydraulic works with the purpose of preventing and mitigating the negative effects of floods. These works can be considered structural measures of protection against floods:

- Vârşolţ Reservoir
- Dams, both on Crasna and Zalău
- Protection works of river beds and banks, also both on Crasna and Zalău

Regarding the non-structural measures we can mention the following aspects:

Crasna Hydrotechnical System with the work formations:

- **Vârşolț – Crasna upstream Formation** with activity at Vârşolț Reservoir and the hydrografic network upstream the reservoir;
- **Crasna downstream - Zalău Formation** with work points at Zalău and Sărmăşag and activity in Crasna and Zalău drainages.

S.G.A. Sălaj Dispatch ensures permanency at the headquarters with trained personnel and the functioning of the information flow in the event of dangerous hydro-meteorological phenomena.

Regarding the alarming of the population there are alarming-warning systems in the basin placed at halls. In Zalau there are 29 alarming-warning sirens and 8 such devices in Simleu-Silvaniei. There is one alarming-warning siren at Vârşolț Reservoir, supplied from the electric network which gives signals in case of dam breaking. The County defence plan against floods established defence measures at a local level as well as measures and ways of defence at the level of hydraulic works.

CONCLUSIONS

- On the basis of primary data the hazard map was drawn, resulting that over half of the research area (64.34%) shows a medium potential of landsliding
- The situation is the other way round in the case of soil erosion, over half of the surface of the basin (63,31 %) being represented by terrains with very low erosion (between 0 – 0,05 t/ha/year). Only 0.24 % of the surface (1.9 km) represents surfaces with erosion of over 6 t/ha/year meaning that the problems are punctual and the solutions need to be found at a local level.
- Low erosion leads to a low silting rate of Varsolt Reservoir, this having a silting time of 252 years, a decent one taking into account the characteristics of the drainage.
- There are favorable conditions regarding the issuing of dangerous hydrological phenomena, rainfall being the main factor.
- The rainiest months are June and July, followed by May and September, which correlated with the high values of liquid flow in this period lead to the most dangerous hydrologic phenomena
- Social, ecological and especially economic effects were recorded.
- The extent of damages is also explained by the fact that almost one third of the surface of the basin is occupied by river meadows
- The exposure is as high as almost half of the researched territory (41.18%) is used as agricultural land

- The great number of damaged households shows the fact that the population uses for inhabiting places exposed to flooding risk
- The large surface of affected agricultural land is explained by the fact that it is well known that the river mwadows are the most fertile lands and it is considered that the benefits overcome possible losses
- Analysing the flood risk maps we can notice the extremely important role of the hydraulic improvements and especially of Vârşolț reservoir in mitigating the possible effects of floods.
- In Crasna Basin the structural defence measures against floods are harmoniously combined with the non-structural ones in order to offer the population the best protection against the unwanted effects of these phenomena and also to minimize damages when they take place
- Unfortunately no measure can offer absolute protection against the negative effects of natural phenomena. Inspite this, the drawing of risk maps, knowing the localisation and the intensity of the phenomena that may take place are really usefull for taking the most adequate measures for protection and for minimising the bad consequences of the natural processes, either hydrologic and geomorphologic.

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