”BABEŞ-BOLYAI” UNIVERSITY

CLUJ-NAPOCA

FACULTY OF GEOGRAPHY

ALMAS HYDROGRAPHIC BASIN STUDY OF APPLIED GEOMORPHOLOGY

Ph.D. Summary

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KEY-WORDS: *Almas Basin, methodology, susceptibility to landslides, soil erosion, morphometry, morphology, sustainable development strategy.*

Acknowledgments

An important and defining step in my professional development is about to complete. It is about a step that embodies aspirations and the desire to research and to improve in geomorphology, in a great potential area, as I like to define “Almas area” – which is also the subject of my Ph.D. thesis.

To elaborate this work, I have received step-by-step guidance from my mentor, Prof. Dr. Ioan-Aurel Irimus, to whom I am thankful for having shaped and opened my mind in this field. He has also made an impression on my professional development, by giving advice, paying attention and continuously focusing in this direction.

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As any objective achieved in our career involves family, I hereby thank to my grandmother, my sister and my family, my close friends that have been unconditionally beside me, as well as my colleagues from Vocational High School No. 1 Surduc, for their understanding during my Ph.D. studies.

I always wanted to aspire to something special, towards a target that offers complexity from all points of view – and this is reasoned by the fact that I had the chance to learn from an example that taught me to see the world as a man and geographer in the same time. He was the one that opened my world as a father and as a teacher, as he showed me the real beauty of the world.

I hereby dedicate this Ph. D. thesis to father’s memory, professor Ioan Rus.

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CHAPTER I. INTRODUCTION

1.2. Motivation of the subject and study objectives

The present work aims to analyse the physical and geographical features of the studied territory, of the forms and types of relief, of morphological and morphometric features of Almas Basin, as well as the way they reflect in the use of lands and in the sustainable development of the area.

The motivation of the subject of the research project is based on a solid ground, namely the fondness and passion for geomorphology that led to the will to research the landscape of Almas Basin, an exponent of native space. These have been supported by the following realities: geographical studies on Almas Basin are general, meeting most of the times the attributes – rather related to geographical monography than to specialized study – the predominance of knowledge and investigation themes of human geography and less of integrated geography themes, as well as the lack of applied geomorphology studies.

The objectives of this study have been set in such a manner that, once achieved, the work content is integrated and connected to the actual context of geography, at a regional, national and international level.

The general objectives of the survey are the following:

- ✓ Implementation of geomorphology knowledge to find solutions on restrictions generated by landscape specific features, in view of an efficient, rational and sustainable use of Almas area;
- ✓ Analysis of Almas Basin landscape, as support for territory development;
- ✓ Assessment of susceptibility and vulnerability in geomorphologic processes, the improve the complex relationship human being- landscape, respectively natural environment;
- ✓ S.W.O.T. analysis of Almas Basin;
- ✓ Identifying a sustainable development strategy of Almas Basin.

Almas Basin, defined by its valuable geographical, geomorphologic and geological potential, by harmonising specific elements of a geomorphologic system, represented, on one hand, a challenging to approach, while on the other hand, a source of wealth and research satisfaction.

1.4. Research methodology

The passion of a geomorphologist for landscape research means, most of the times, admiring the shapes modelled by different agents, with fondness and delight. It also represents the glitter and excitement to discover new geomorphological sites, or the satisfaction to join a process in evolution and to get involved when human-nature balance declines.

The study of a hydrographic basin becomes so complex that it often involves the desire to postpone the completion of a research stage, because of the impulse to complete and add the new phenomenon - hence, the complexity of the research and of the adopted methodology.

Generally, the working methodology consisted in compliance with essential milestones in achieving this study, such as: the preparatory stage, the filed stage, the systematisation stage, data reading and analysis and drafting stage.

Data reading and result analysis supposed the following actions: data organisation and processing by statistical-mathematical methods and GIS analysis, as well as implementation of thematic maps and cartographic supports by the following methods: remark, experimental, morphometric, morphographic, statistical-mathematical comparison, as well as the use of GIS technique.

GIS technique (Geographic Information System) was used to generate certain spatial analysis methods that led to the analysis and implementation of the cartographic basis for Almas Basin (digital elevation pattern, slope map, fragmentation depth map, fragmentation density map, slope orientation map, etc.), to the implementation of the method to calculate the frequency rate of landslides (Fr) and of the susceptibility index (LSI), to the definition of the annual average rate of soil erosion in Almas Basin by means of USLE and GIS techniques, to the analysis of morphometric parameters and their suitability for territory improvement in Almas Basin, etc. The patterns used in this study were possible by means of ESRI products and its options: ArcMap 10.1, Quantum GIS 1.7.0, as well as Global Mapper programme.

CHAPTER II. ALMAS BASIN- GEOGRAPHICAL LANDMARKS

2.1. Geographical location and boundaries

Almas Basin, situated in the North-West side of the country, in the marginal unit of Transylvanian Depression, is the transition path between Somes Plateau platform and Meses Mountains Orogene (see Figure 2). Almas and Agrij (two valleys with almost parallel courses), have contributed to the Holocene morphology completion of Almas-Agrij Depression. (Irimus, 2003, Rus, Irimus, 2015). This represents "*the last marginal component of the western side of Transylvanian Depression, well defined by higher units on all its slops*" (Pop, 2001, p. 106).

The limits of the Basin are represented by the watershed that separates Almas Basin from Agrij Basin on the West, from Crisul Repede Basin on the South, from Somesul Mic on the South-East and East, as well as from Valea Garboului Basin on the North-East.

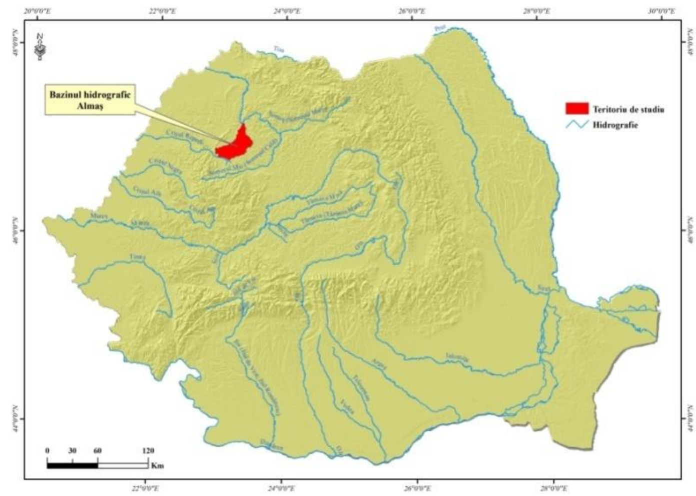


Figure 2. Geographical position of Almas Basin

2.2. Lithology and tectonics- prerequisites of exogenous modelling

Almas Depression, situated in the North-West periphery of Transylvanian Depression, met a paleogeographical evolution closely related to the great unit that comprises it.

From the geological point of view, Almas Basin, measuring 814.5 km2, is part of Eocene, Oligocene and Miocene lower lithologic deposits.

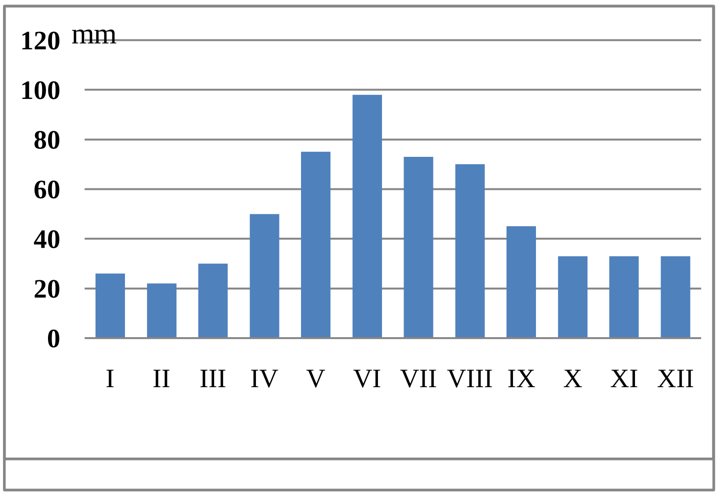
The Eocene in the upper basin, especially Probonian Eocene featuring lower coarse-grained limestone, sandstone, upper striped clays and marl, led to weak branching of upper courses for the right-side affluent: Jebuc, Valea Cetatii and Petrindu.

The Oligocene formed by Mera strata (Lattorfian), featuring marn and purple-green sandy clay, slightly layered, together with green sands, calcareous sandstone and coarse-grained limestone, is located over Eocene strata. This is represented by a narrow strip of land that makes the transition to the second horizon typical to Oligocene: the Rupelian (Ticu Strata), widely extended in the upper basin of the valley. The aquitanian-chattian formations (Zimbor and Sanmihai strata) are widely spread in Almas Basin. In the daytime, they appear in the middle basin on a wide surface, and downstream from Hida they are covered by the latest formations. They reappear in the daytime only in the lower course, downstream from Galgau. The Oligogene closes with Sanmihai strata, with red clays featured by gravel that make the transition to lower Miocene (Burdigalian and Helvetian) – namely conglomerate, sandstone, marl clay, widely developed on the right side of Almas river, starting downstream from Hida up to Galgau-Almas.

The confluence with Somes River on the north side of the basin and the outing from the depression modify the relation between Almas River and geological structure and lithology, which led to the decrease of basin width at the level of lower Miocene deposits, aquitanian-eggenburgiane (Krézsek & Bally, 2006, Filipescu, 2011).

2.3. Climate prerequisites of landscape modelling in Almas Basin

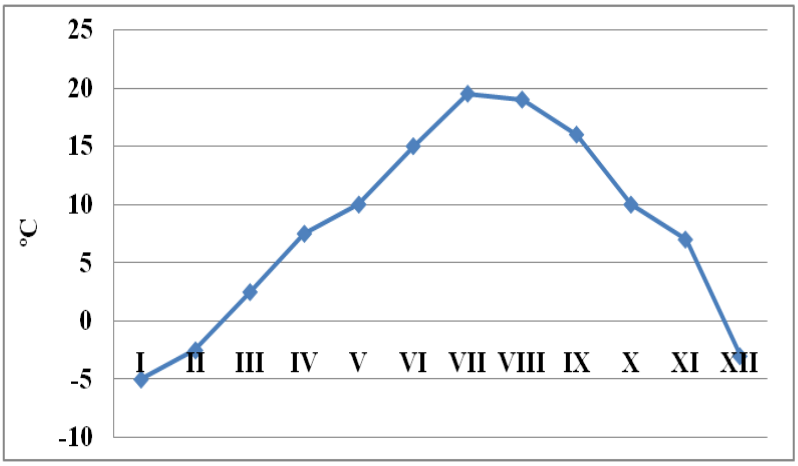
3.3.1. Precipitations



Almas Basin features the maximum quantity of precipitations between April – September (see Figure 8), especially in June, when more than 90 mm are registered. The lowest quantity of precipitation is registered in January (25 mm) and February (30 mm).

Figure 8. Monthly average quantity of precipitations between 1971 and 2000 *(pursuant to Blaga, 2013)*

2.1.1. Temperature



Temperature is the climate element influencing first the surface leakage and evaporation; the air temperature influence on groundwater decreases with depth.

Figure 11. Monthly average temperatures in Almas Basin

The annual average temperature is marked by 8.5°C isotherm and emphasises the Almas Basin shelter. The highest annual average temperatures occur in summer time (July: 19°C, August: 18°C), while the lowest ones occur in winter time (January: -5°C, February: -1°C), see Figure 11.

2.1.2. Main ice configurations

Temperature is the main factor that causes the frost and its related forms. The diversity of the ice is also influenced by other factors: predominance of polar circulation in winter time that influences the air temperature, flow velocity and flow turbulent nature, as well as river morphometric peculiarities. The main ice configurations on Almas River and its affluent are the following: shore ice, floes, ice bridge, overlapping layers of ice.

CHAPTER III. HYDROLOGY OF ALMAS BASIN

3.2.2. Floods in Almas Basin

According to data provided by Somes-Tisa River Basin Water Administration, the main floods on Almas River occurred in the following period: 1970, 1974, 1975, 1978, 1979, 1980, 1981, 1989, 1993, 1995, 1998, 2000, 2001, 2008, 2010 and 2012. Hydrometric stations in Almas hydrographic Basin are Almasu and Hida. As for Almas Basin, the highest monthly frequency of floods occurs in May, while the lowest, in September and November. As for the seasons, the highest record occurs in spring time (50-56.4% of the total of floods), while the lowest, in autumn time (7-8%), Figure 23, (Dumitra, 2008).

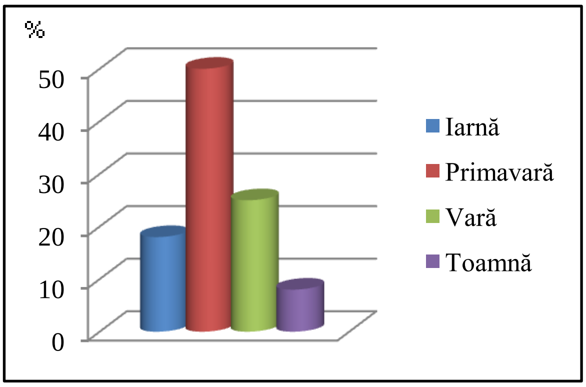


Figure 23. Seasonal frequency of floods on Almas River

3.3.1. Chronologic variation of annual average leakage between 1990 and 2004 at Almasu and Hida treatment works

Between 1990 and 2004, the highest flow recorded 3.58 m^3/s at Hida plant, and the lowest flow recorded during this period on Almas River was 0.271 m3/s at Almasu plant. The representation of chronological variation of annual average flows was made by means of module coefficients, calculated as ratio between the annual average flows and term average flows (K=(Qa/ Qm)).

The term average flow recorded at Almasu plant (between 1990 and 2004) was 0.596 m^3/s, remarkably less than the term average flow recorded at Hida plant (1.536 m^3/s).

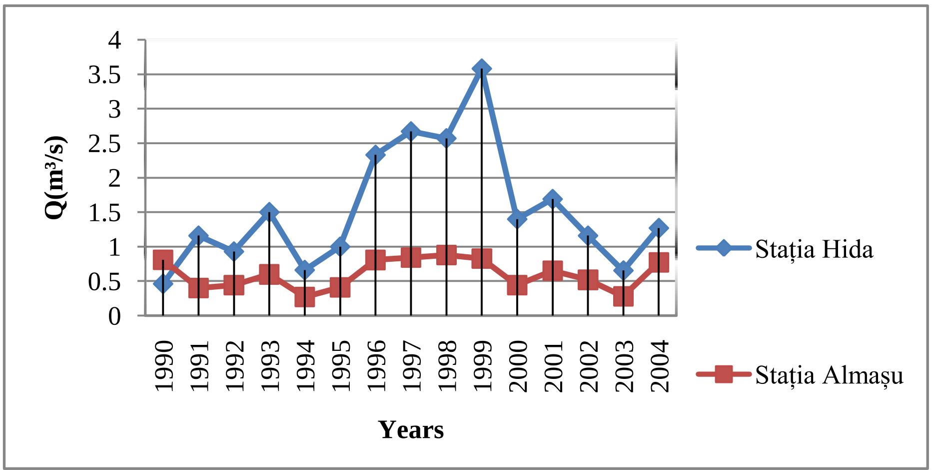


Figure 47. Annual average flow between 1990 and 2004 at Almasu and Hida treatment works

CHAPTER IV. ALMAS BASIN LANDSCAPE - SUPPORT OF TERRITORIAL DEVELOPMENT

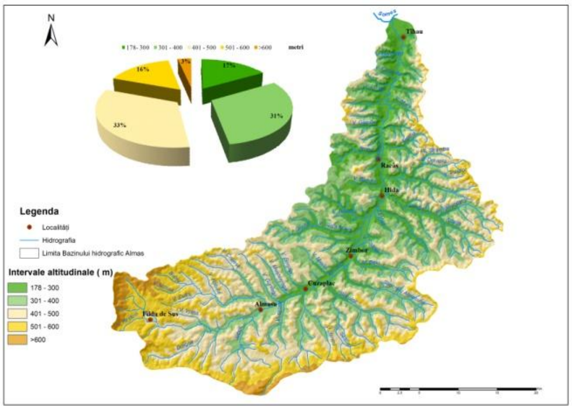
4.1. Basin morphometry – prerequisite for territory development

The morphometric features of the landscape of Almas hydrographic basin reveal the spatial distribution and the evolution stage of landforms, as well as the intensity and types of geomorphological processes.

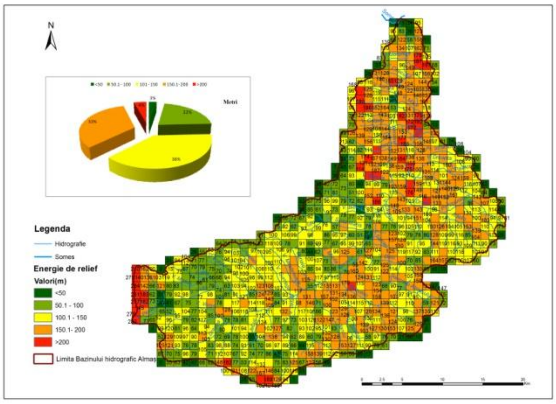
4.1.1. Basin morphometric features

Almas hydrographic basin is surrounded by the following hydrographic basins: Agrijul on West, Crisul Repede on South, Nadas, Borsa, Lonea (all related to Somesul Mic hydrographic basin) and Girbou (related to Somes hydrographic basin) on East and is confluent with Somes River on the North side. Its total surface is 814.5 km^2, representing 5.17 % of the entire surface of Somes hydrographic basin (15,740 km^2). With its 814.5 km^2 surface, Almas is the greatest sub-basin of Somes River, on the left side downstream from Dej locality.

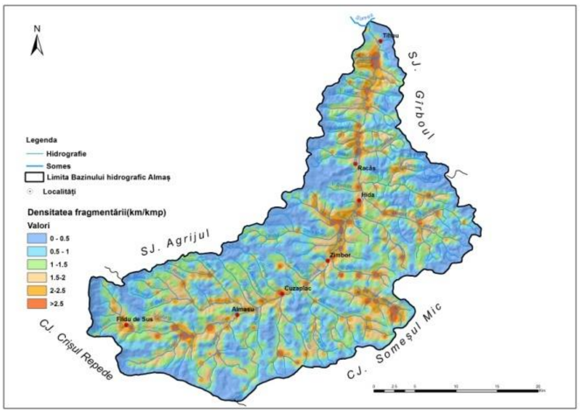
4.1.2.Hipsometry



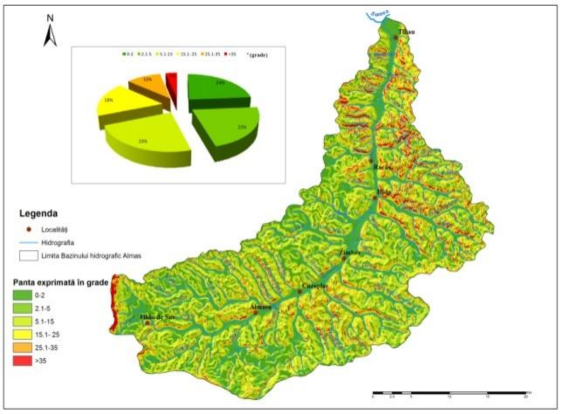
4.1.3. Fragmentation depth



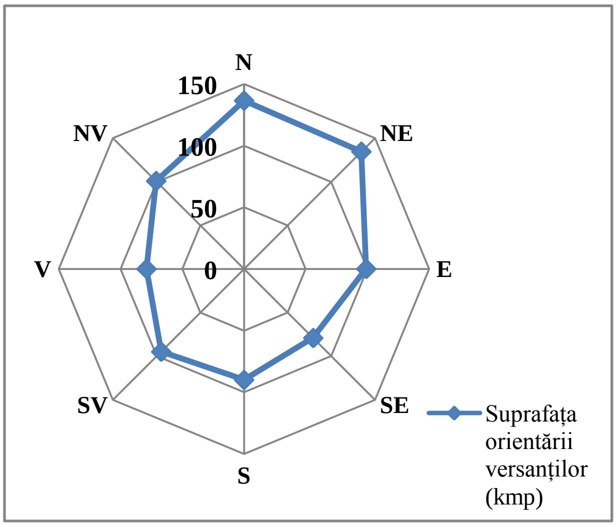
4.1.4. Landscape fragmentation density



4.1.5. Slopes geodeclivity



4.1.6. Orientation of morphological surfaces



The SW – NE course orientation of Almas River (in the upper and middle course) and predominantly the North orientation (in the lower course) influence and define the slope orientation type. The analysis of slope orientation weighting led to the following results: the largest area of slopes (in the basin area) are oriented towards North and North-East, followed by northwest-facing slopes (12.3 %) and east-facing slopes (12.2 %), while the southeast-facing and west-facing slopes record the lowest weighting.

4.1.2. Hierarchy of hydrographical network. Horton-Strahler ordering Law

The hierarchy of hydrographical network of Almas sub-basins was performed by means of Horton-Strahler classification system.

As for the studied hydrographic basin, is has been assigned to the 5th order (Almas River). This is followed by 4th order basins (Pestera, Babiu, Petrindu, Bozolnic, Sancraiul Almasului, Santa Marie, Valea Mare, Dragu, Voievodeni, Printre Vai, Trestia), by 3rd order basins (Dorogna, Jebuc, Martin, Taudu, Valea Cetatii, Dincu, Arghis, Mierta, Dolu, Ugrutiu, Stramba, Jirnau), by 2nd order basins (Benaia and Guiaga) and by 1st order basins (Mestereaga).

4.2. Almas Basin morphology – prerequisite for territory development

Overall, the landscape of Almas basin, featuring broad and terraced valleys, narrow and short ridges, with low interfluves, and entirely altitudes lower than neighbouring units, presents as a depression, located next to Agrij Depression on the East side of Meses mountains. The long-evolution erosion has generated the actual landscape, while it continues to be the most active factor in landscape dynamics.

The erosion acts differently across the basin, due to substrata features, to Geodeclivity, to landscape energy, to vegetation, etc. Considering all these conditions and the diversity of landscape created under their influence, Almas Basin may be divided into three main subdivisions, with distinct morphologies: the upper, the middle and the lower basin.

4.2.1. Actual and contemporary geomorphologic processes

The wide range of geomorphological processes is widespread in Almas basin area. Generated by a number of factors, geomorphological processes act continuously on the surface of the basin, modifying the landscape aspect, as the main influence of these processes is soil degradation. Therefore, it is necessary to identify such processes, to know their root causes, their mechanism and evolution trend, in order to take practical measures to prevent and combat the negative effects. The actual geomorphological processes, together with other features of Almas hydrographic basin, lead to a geomorphological regionalization, adjusted to hypsometry, slopes, geology, as well as to land use mode.

The geomorphological processes with the greatest impact on Almas basin morphology, as well as restrictive factors in land use are the following: surface erosion processes, deep erosion processes, landslides.

4.2.4.1.Implementation of USLE model by means of GIS techniques

The values of the annual rate of soil erosion related to Almas hydrographic basin vary between 0 and 40.27 t/ha/year. The erosion average ratio is 0.16 t/ha/year, and the maximal one is 40.27 t/ha/year (Table 57). As for the basin surface (814.5 km²), the absolute soil erosion rate on erosion intervals is the following: 68% of the basin surface is affected by erosion whose values vary between 0 and 1 t/ha/year, 25% (1-2 t/ha/year), 5% (2-3 t/ha/year), 1% (3-4 t/ha/year), 0.5% (4-5 t/ha/year) and 0.5 % (erosion values more than 5 t/ha/year).

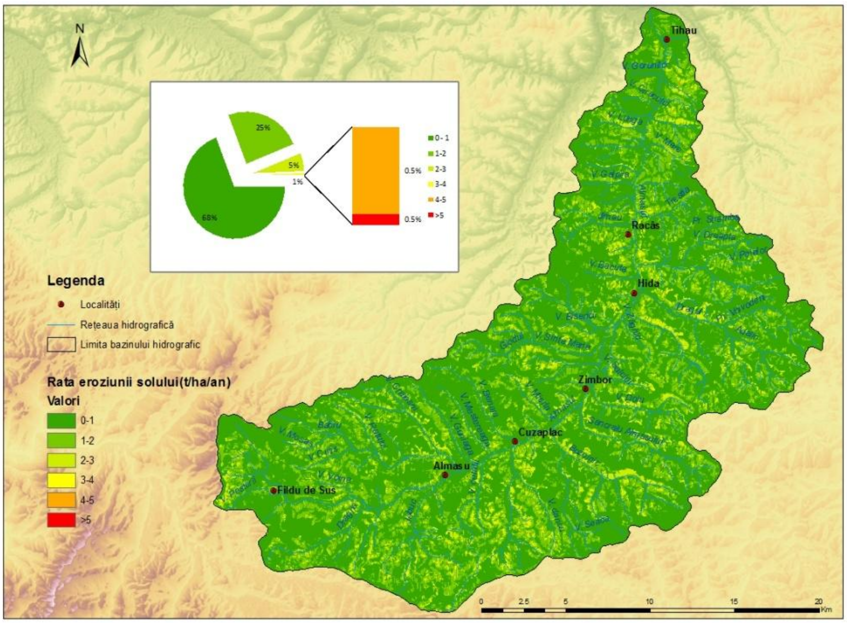


Figure 130. Space distribution of the annual rate of surface erosion *(pursuant to Irimuș, Rus, 2015, p. 1076)*

4.2.5. Implementation of calculation model of landslide frequency rate (Fr) and of the landslide susceptibility index (LSI), by means of GIS techniques

Analysing the morphology, morphometry, geology and Lithology of Almas hydrographic basin, it seems that this area is exposed to geomorphological processes, especially to landslides; consequently, I considered appropriate an assessment study that describes the relation between the frequency and the distribution of landslides and of influencing factors, by implementing the calculation model of the frequency rate of landslides (F_r) and of the susceptibility index (LSI), by means of GIS techniques.

As for Almas hydrographic basin, LSI index (landslides susceptibility index) is at least 7.16, at last 21.8 and on average 16, using a deviation standard of 2.41. The implementation of calculation method of landslides susceptibility by means of the frequency rate method and of GIS techniques, led to the following results: 37.73% of Almas Basin features very low and low values of susceptibility (between 7 and 13) and mainly feature the upper basin, as well as Almas passage and its most affluent; 37.99% of the territory is defined by values of landslide frequency rate between 15 and 18, by a moderate landslide susceptibility (middle and lower basin, piedmont Meses area);

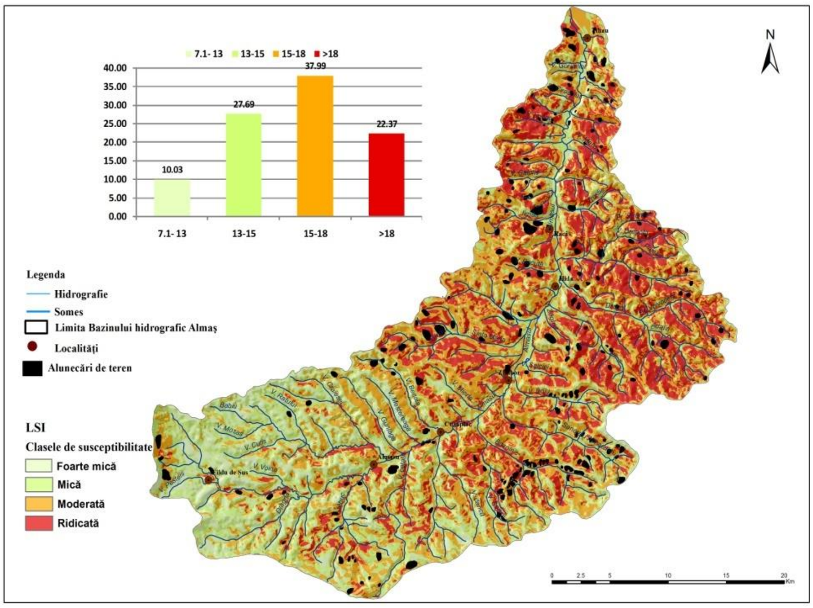


Figure 107. Landslides susceptibility classes

The highest susceptibility values feature the 182.11 km² area (22. 37 %). The areas included in this class of susceptibility are the middle and the lower basin that overlap the Oligocene geological area (chattian-aquitanian) and especially Miocene areas (Helvetian and burdigalian).

CHAPTER V. USE OF LANDS IN ALMAS BASIN

5.1.1. Situation of land by land use categories, when it comes to Basin

The structure analysis of land use in Almas hydrographic basin revealed the presence of 10 types of land use. According to CORINE Land Cover 2006 database, the agricultural fields cover 44970 hectares (54%) of the basin surface, while the non-agricultural fields cover 36480 de hectares (46%).

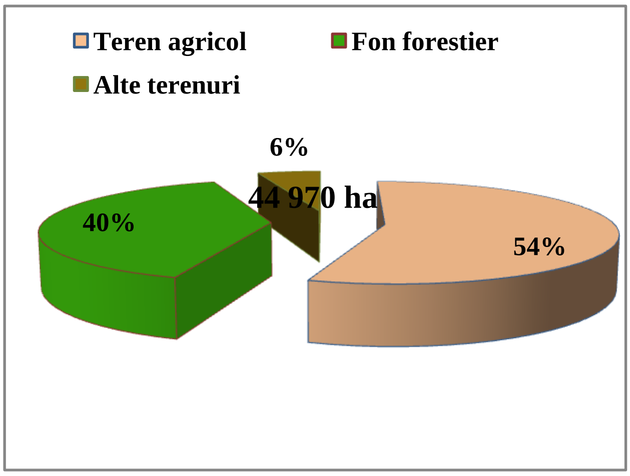


Figure 111. Structure of land use

5.1.2. Situation of land by land use and owners categories, when it comes to territorial and administrative divisions of Almas Basin

The land analysis by land use and owners categories included the eight territorial and administrative divisions whose surface is entirely covered within the limits of Almas hydrographic basin.

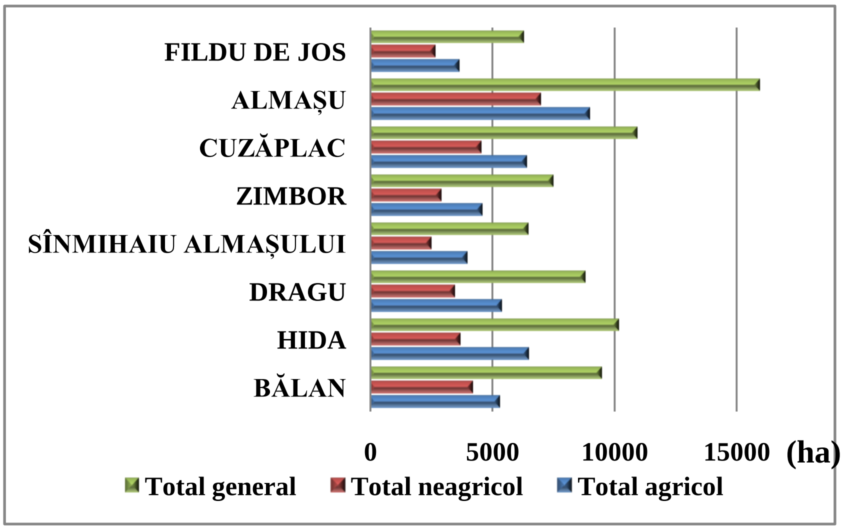


Figure 113. Situation of Land on 31.12.2011, territorial-administrative divisions

CHAPTER VI. LAND IMPROVEMENT WORKS IN ALMAS BASIN

The first improvement works in Almas hydrographic basin have been performed in 1958, as represented by hydrotechnical works in order to prevent floods in the following localities: Hida, Racas, Dragu, Baica, within Valea Almasului and Valea Dragu riversides. Land improvement works have also been performed in 1979 in ESC (Economic and Social Council, *transl*. Consiliul Economic si Social) Almasu Superior, while most of the works have been performed during 1980 and 1991, featuring 20-25 years lifetime, some of them even 30 years lifetime, namely: 516 ESC Almas Mestereaga, 517 ESC Almas Petrindu Ruginoasa, 518 ESC Almasu Superior, 550 ESC Bercea Santamarie, 625 ESC Zimbor, 624 ESC Fildu, 639 ESC Sincraiul Almasului. Consequently to 1990, the activity in land improvement works has been reorganised with each political management, which led to discontinuity and ambiguity in elaborating and implementing viable maintenance and repair programs, especially in what concerns the investments.

CHAPTER VII. SUSTAINABLE RURAL DEVELOPMENT OF ALMAS BASIN

7.2.1. Assessment of morphometric parameters and suitability to territorial planning in Almas Basin by means of GIS techniques

The generated map of surfaces suitable for human activities show that 53% of Almas hydrographic basin surface features areas with low suitability for developing human activities, while 47% features areas with medium-higher suitability for human activities.

7.2.2. Natural, human and tourist resources in sustaining Almas Model

7.2.2.1. Human resources

The population located in Almas Basin represents 7.27% of the total population of Salaj County, while the demographic size of rural settlements, namely 57, varies from 11 inhabitants in Stoboru locality to 1067 inhabitants in Hida locality.

7.2.2.2.Natural and tourist resources

The natural resources of raw material available in Almas hydrographic basin are the following: carbonaceous shale (Zimbor), alabaster (Galaseni and Stana), kaolin (Ruginoasa), kaolin sands (Cublesu), river aggregates (Almasu), brown coal deposits (Hida, Dolu, Miluani, Chendrea and Ugrutiu). Natural resources within Almas hydrographic basin are represented by agricultural fields, holding a remarkable proportion in the basin unit (54%) and from the forest also (40%), from which 37% represent deciduous forests.

According to the situation of tourist sites, there are 21 wooden churches, 5 reformed churches, 5 castles and mansions, 1 citadel, 3 natural reservations and 3 archaeological sites, as presented in Figure 135.

7.3. Strategy for rural sustainable development of Almas Basin

The identification and implementation of the sustainable development strategy in Almas hydrographic basin was possible by reference to the national, regional and county contexts.

The strategy identification approach was based on the diagnosis of Almas area by means of S.W.O.T. analysis of the three components, namely: natural, social and economical.

CHAPTER VIII. CONCLUSIONS

Almas hydrographic basin is situated in Almas-Agrij Depression and features 388 metres altitude. It also features a rural character, as agricultural fields prevail in 54% ratio, as well as by its geomorphological and geological potential and by the diversity of tourist sites. All these things formed and continue to represent the development premises for Almas space, namely Almas hydrographic basin, with a total surface of 814.5 km².

The potential of a sustainable rural developments exists, but the rural environment, still poor, does not feature a medium or maximum capitalization capacity, or an integrated strategy that ensures its functioning, development and evolution as a whole. The strengths in this respect are represented either by completed projects or by ongoing projects in design that have been started within territorial and administrative unities or by the county administration. Following the strengths identified by means of S.W.O.T. analysis of the natural, social and economical components, two solutions for efficient and sustainable functioning of Almas basin have been identified. The natural, economical and social advantages of Almas area have been already mentioned in Chapter VII of the study, within the diagnosis performed by means of S.W.O.T. analysis. The identification of these strengths featuring Almas hydrographic basin led to the implementation of two possible options of sustainable development: on one hand, the unitary functioning of territorial and administrative units within a Local action Group – reasoned on rural space continuity, and on the other hand, at a county level, the entire basin may represent a Territorial Planning Unit, either individually, or in relation to Agrij Basin.

The proposal that Almas basin functions as micro-zone or as Territorial Planning Unit, either at a county level, or individually, or in relation to Agrij Basin, is based on the following reasons: the morphological identity and the morphometric features of a depression, the advantage of functioning as a whole defined by the geomorphological system of the hydrographic basin, the highlighting of the rural characteristic by means of original and identity elements featured – first of all- by its continuity and by the distinctive operation mode.

In conclusion, Almas hydrographic basin, a space highlighted in Salaj County by multiple specific elements, comprises all prerequisites of a sustainable and intelligent development that needs to focus on strategies based on opportunities offered by its own space in order to ensure territorial cohesion.