"BABEŞ-BOLYAI” UNIVERSITY
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PhD. Thesis
Abstract

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RIVER WATER RESOURCES IN CĂLIMAN MOUNTAINS. SPATIAL AND TEMPORAL ASSESMENT AND REPARTITION

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SUMMARY

Key words: water resources, Căliman Mountains, hydrographic network, flow, evaluation of water resources, spatial distribution, temporal distribution, temperature, precipitation, snow layer, water regime, large waters, floods, small waters, regime types.

CHAPTER I. INTRODUCTIVE ASPECTS

1. Geographic position and limits of Căliaman Mountains

The Căliman Mountains occupy the northwestern part of the central group of the Eastern Carpathians, representing the largest volcanic massif in our country, being severely detached from the neighboring regions by obvious depression areas - in the west Colibița, in the north the Dornelor Depression, the Neagra Șarului, in the east Drăgoiasa, Glodu, Bilbor, Secu, and in the south the defilee of Mureș River that separates them from the Gurghiului Mountains. They have a maximum altitude of 2100 m at the peak of Pietrosu Călimanului, their shape resembles a rectangle with a length of 60 km on the west-east direction and a width of 30 km from north to south, with an area of about 2000 km^2 including areas on the territories of Suceava, Harghita, Mureș and Bistrița-Năsăud counties (Fig 1).

Regarding the terminology of the Căliman Mountains, it is very scientifically correct, the variant of the Căliman Mountains and not the Călimani Mountains, with "i " as it is very often used. In the geography treaties of the Romanian Academy, in the work “Water and Landscapes of the Căliman Mountains” of Iulian Dincă, and in numerous scientific works the form is of the Căliman Mountains.

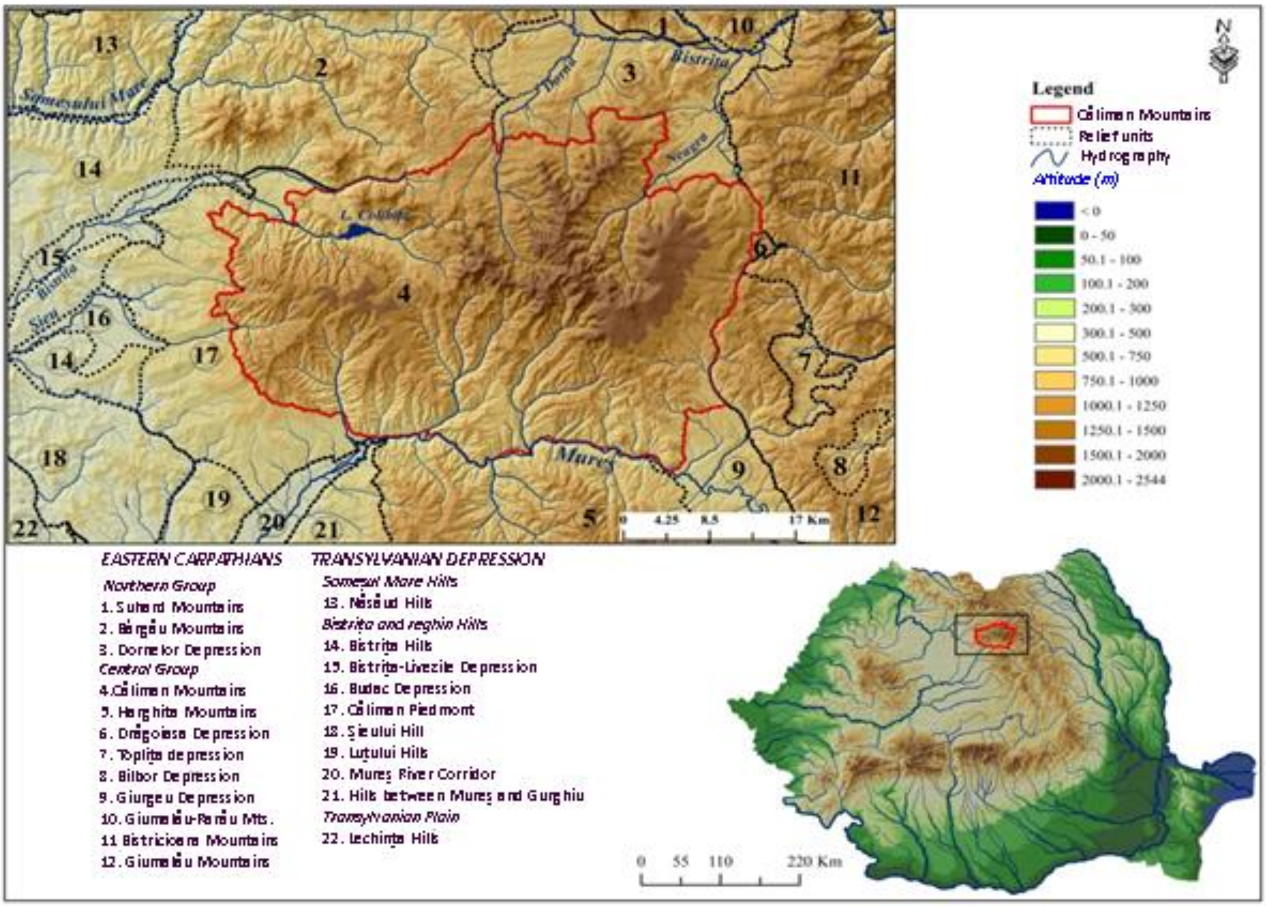

Fig.1. The plasament of Căliman Mountains in the national context

1. Geographical features of Căliman Mountains

The volcanic chain on the western side of the Eastern Carpathians led to the completion of this chain, to its structural complication, but also to the increased diversification of the relief, which is why, at the scale of the whole country, the volcanic relief cannot be considered as subordinate to the other relief categories, being formed on sedimentary and metamorphic rocks, but on the contrary, represents a category with a particular style of forms, recorded as such in all the maps and works intended for relief (Geography of Romania, vol. I, 1983).

As can be seen from the hypsometric map, the maximum altitude is 2100 m at Pietrosul Peak, then Negoiu Peak 2081 m, Rețițiș Peak 2020 m, Iezerul Călimanului Peak 2031 m, Căliman Peak 2012 m, and Bistricioru Peak 1989m. The altitude values over 1900 m are arranged in the form of arches in the central-northern part of the massif, where the volcanic craters are sheltered. The values between 1000-1400 m occupy the most significant areas of the Căliman Massif. The Pietrosul Peak inscribes the Căliman massif in the series of the highest volcanic buildings from us in the country, being the first place.

2. The organization of the river network in Căliman Mountains

In the Caliman Mountains on the most frequent cases, the rock and the slope factor, less the tectonic lines, impose the way in which the hydrographic axes build their valleys, from the smallest to the highest orders. The analysis of the number of segments of watercourses that discover the order of their size was done on the basis of the Horton-Strahler system.

Table 1. The size order of the rivers in the three river basins

Hidrography *(Horton-Strahler System)*	**Siret River Basin**		**Someș River Basin**		**Mureș River Basin**		**Căliman Mountains**	
	Length (km)	*Density (km/km²)*	*Length (km)*	*Density (km/km²)*	*Length (km)*	*Density (km/km²)*	*Length (km)*	*Density (km/km²)*
I	285.60	0.68	290.40	0.88	550.77	0.81	1153.65	0.81
II	116.69	0.28	86.72	0.26	174.97	0.26	397.66	0.28
III	42.53	0.10	32.84	0.10	79.38	0.12	166.28	0.12
IV	20.89	0.05	12.88	0.04	42.21	0.06	88.40	0.06
V	7.72	0.02	12.21	0.04	18.65	0.03	42.47	0.03
VI	-	-	-	-	1.40	0.002	25.96	0.02
Total	**473.44**	**1.13**	**435.05**	**1.32**	**867.37**	**1.28**	**1874.42**	**1.32**

The length of the Căliman Mountains hydrographic network is 1874.42 km and has a density of 1.32 km/km^2. Analyzing this table in detail, it turns out that out of the total of 1874.42 km, 1153.65 km are rivers of the first order of the Horton-Strahler system.

The space of the Caliman Mountains has not been a complete and thorough study of the hydrology of the existing water resources, although geographical syntheses referring to these mountains are numerous.

The organization of the network of rivers in the Caliman Mountains by its shape and structure specific to the volcanic mountains, the rivers radially run their courses, these find tribute to the hydrographic basins of Mures, Someș and Siret (Fig. 3).

In the upper courses the rivers flow through narrow valleys, which widen in the middle and lower sectors. These rivers severely fragmented the lava, carving important access routes to the highest peaks of the volcanic dome.

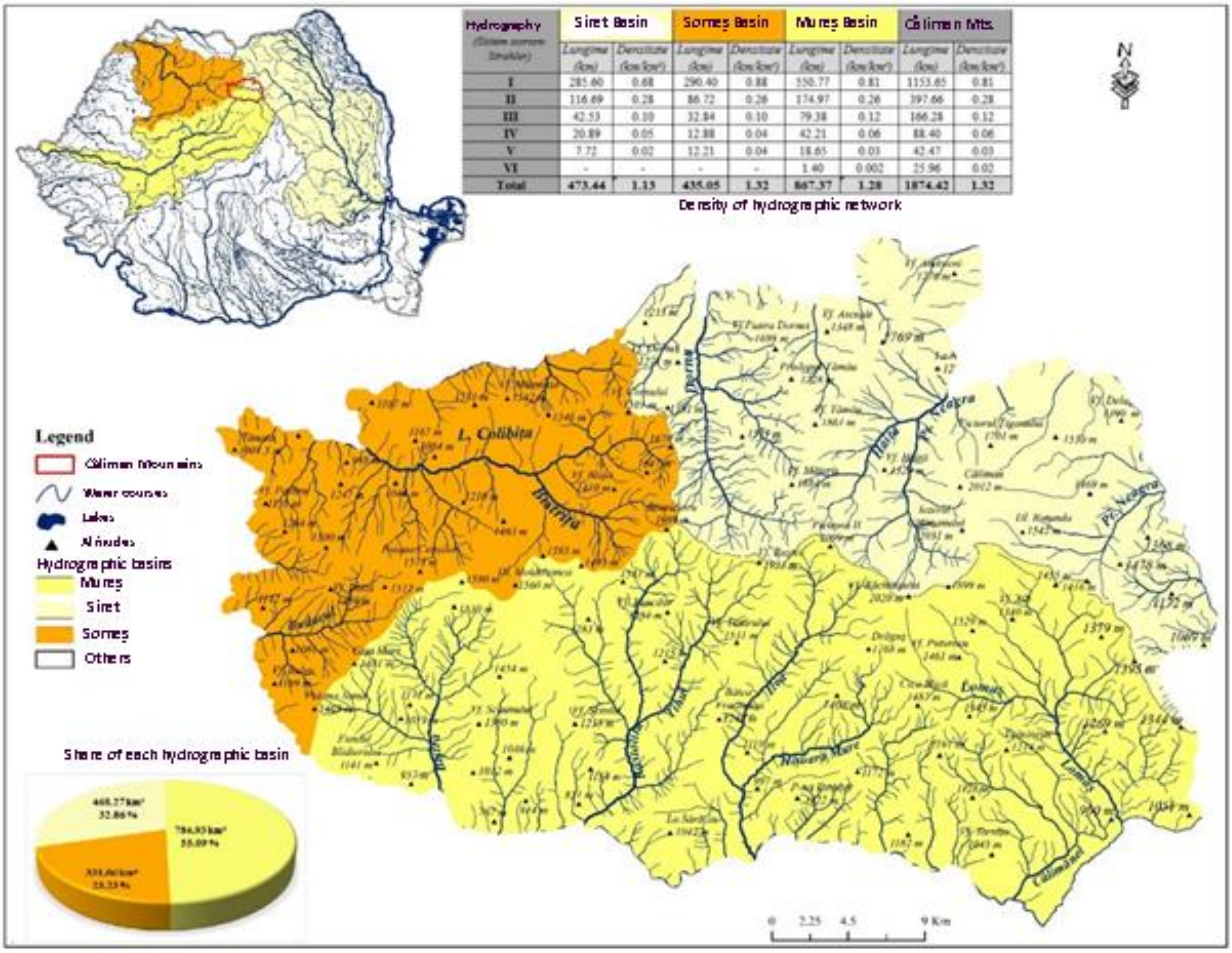

Fig.2. The river network from Căliman Mountains

Very often, the name "dorna" with different diminutives appears, used for naming the most important rivers, of some localities and part of the study area (Dornelor Depression). The place name comes from the name "dorna" of Slavic origin meaning "water whirl", "bulb", because the rivers Dorna and Dornișoara have many longitudinal shores in the longitudinal profile and there are whirlpools installed. Often the names of "dorna" and "neagra" are always interwoven: Șaru Dornei, Dorna Arini, Dorna Candreni, Dornișoara, Neagra Șarului, Neagra Broștenilor, Poiana Negrii. All these aspects of toponymy in this area are of particular importance, as they represent some aspects of the relief, some features of the hydrographic network and explain the appearance and development of human settlements.

Neagra Șarului, receives numerous tributaries: Reșitiș, Dumitrelul, Pietricelul, Tarnița, Băuca, Stănei, Țiganului and Haitii, the latter has the highest flow, the confluence between the stream of Haitii and Neagra Șarului is realized near the locality of Gura Haitii. The length of the river is 17 km, the surface of the basin is 18 km^2 and its springs are at an altitude of over 1500 m. The waters from the northeastern part of the massif are collected by Călimănel, a tributary of the Neagra Șarului River, which marks the contact with the eruptive Călimanului. and the crystalline mountains of Bistrita.

Neagra Broștenilor receives tributaries on the left such as: Tomnatec, Buciniș, Frumușica, Bolovănișul, Lopata, Dragoiasa, Glodu. On the right side he receives a series of tributary princes who: Tarnița, Scăldatori, Haitul and Ciutacul.

Bistricioara is a tributary of Bistrita, crosses the Bilbor Depression, springs from an altitude of 1350 m and has a length of 68 km. It separates the eruptive mountains of Călimanului from the crystalline mountains of Bistrita, at the contact between the two types of rocks numerous sources of mineral water were born. Among the most important tributaries of the Bistricioara we can mention the streams: Borcut, Ruşilor, Dobreanu, Aluniș, Țiganului, Răchitișul Mare, Cetățui and Vinului, the latter being a collector of the hydrographic network from the Borsec depression.

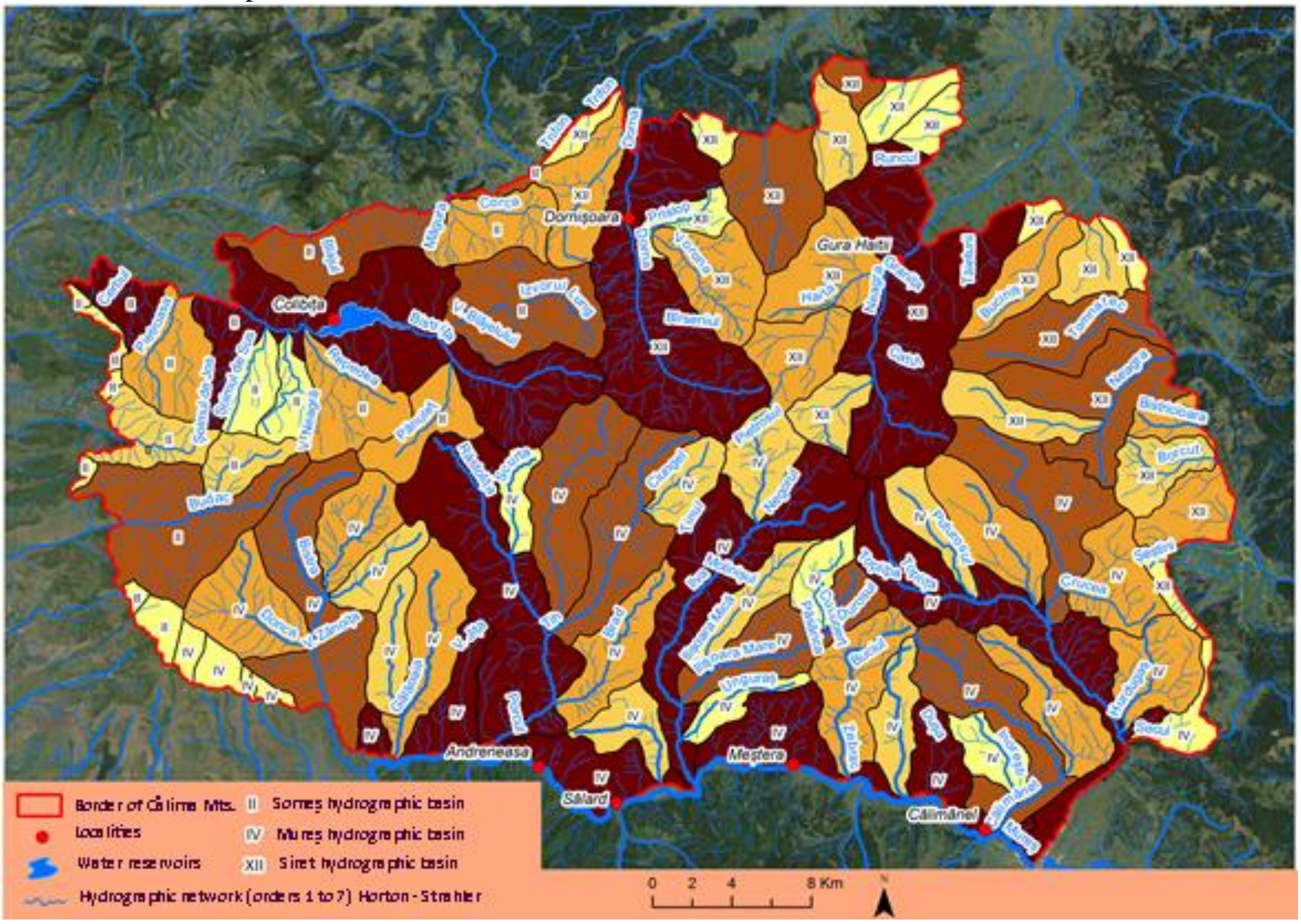

Fig. 3. Map of hydrographic sub-basins

3. Organization of the network of hydrometric and meteorological stations in the Caliman Mountains

In the studied area there are 14 hydrometric stations that monitor the evolution of water quantities from the Caliman Mountains, coming from different sources of power. Seven stations belong to the Siret river basin, ie the north and north-eastern part of the massif, three belong to the Mureș river basin located in the southern part of the studied area, and the last four stations in the sheets belong to the Someș river basin and appear in the western part of the massif. We only considered the stations on the rivers from the Caliman Mountains (Table 2).

In the analysis of the hydrometric network, several growths were considered first, the distribution of hydrometric stations being based on hydrographic basins, after which the distribution of stations by altitude intervals and then the operating period, the program of measurements and observations resulting from the representativeness of the stations and the possibilities of hydrological synthesis.

As can be seen from the operating tables of the hydrometric stations, some stations have been operating for more than 60 years, a special case being Jelna located on the Budac River, which was destroyed in 1998 following a major flood. In some stations there are reconstructed flows because on the Răstolița River, upstream of the hydrometric station a hydroelectric power station operates or in another case on the Bistrița river there are two hydrometric stations, one upstream of Colibița lake, Mița station and one downstream station, Bistrița Bârgăului station, which and this station represents reconstituted debt measurements.

Table 2. Hydrometric stations and their operating period

Nr. Crt.	River names	Hydrological station name	F (km²)	H averg. (m)	Operating period
1	Dorna	Poiana Stampei	100	1376	1961-present
2	Dornișoara	Poiana Stampei	46	1062	1986-present
3	Neagra	Gura Negrii	301	1256	1950-present
4	Haita	Gura Haitii	39	1462	1982-present
5	Șărișor	Panaci	63	1427	1986-present
6	Tomnatic	Drăgoiasa	33	1408	1972-present
7	Bistricioara	Bilbor	88	1123	1976-present
8	Toplița	Toplița	208	1149	1952-present
9	Răstolița	Răstolița	163	1174	1949-present
10	Bistra	Bistra	94	1104	1973-present
11	Budac	Jelna	157	781	1974-1998
12	Bistrița	Mița	82	1230	1974-present
13	Bistrița	Bistrița Bârgăului	612	1130	1948-present
14	Straja	Mureșeni Bârgăului	71	860	1900-present

For the rivers of the Caliman Mountains, a background of conclusive hydrometric data has been accumulated and over a number of years necessary for hydrological syntheses. The hydrometric data were obtained from the headquarters of the National Water Administration of the hydrological basins (Târgu Mureș, Cluj-Napoca and Bacău).

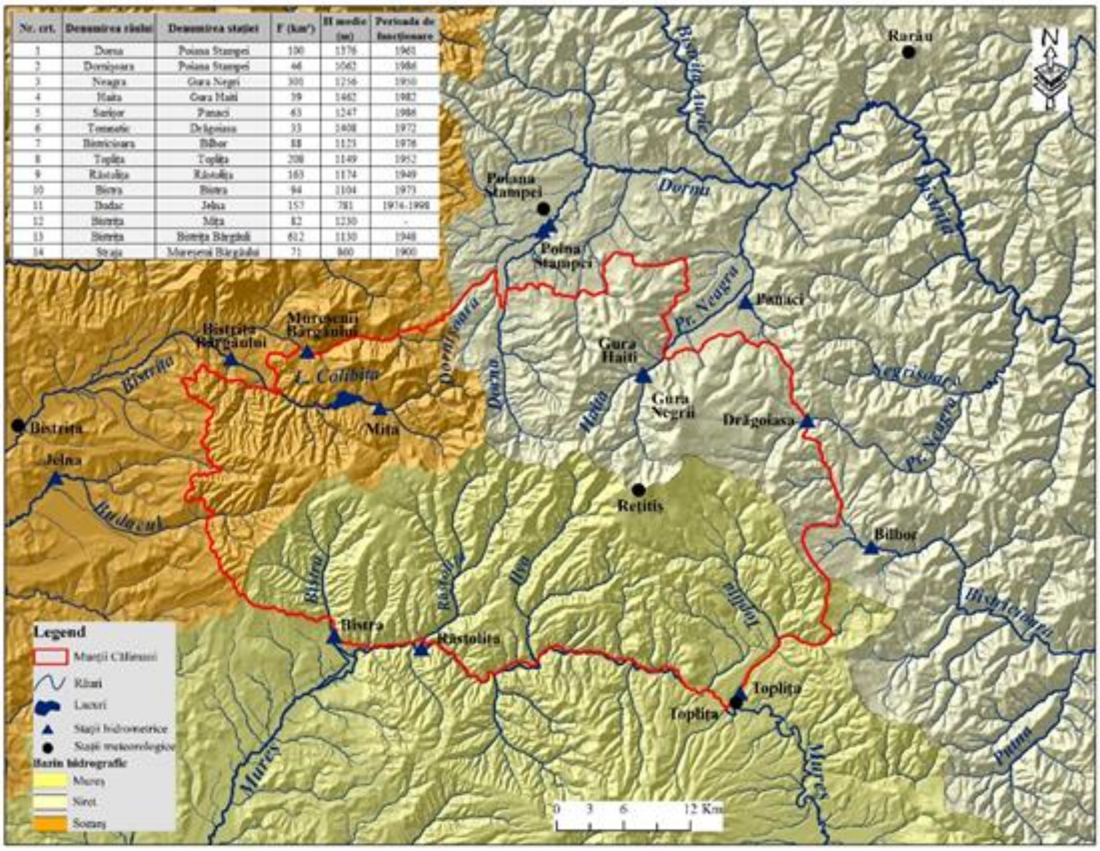

Fig. 4. Repartition of hydrometric and meteorological stations

The data from these weather stations refer to the average monthly temperatures, the amount of precipitation and the thickness of the snow layer, in fact the most important meteorological elements that influence the flow regime of the rivers.

The meteorological stations located in the studied area and used for the climatic characterization of the area are Toplița, Poiana Stampei, Bistrița and Rețitiș.

3. Data base and methods used in the elaboration of the thesis

The quantitative data obtained and used in this paper were processed using several working methods, which are specific to both geography and other sciences, giving the present work an interdisciplinary character.

For the analysis of the tendency of precipitations dropped between 1961-2010, the trend of precipitation quantities was calculated using the first degree equation of the Excel program for intervals of different lengths (one month, three months - seasons, six months - seasons, year). Trends were calculated for the entire interval, determining the general trend of precipitation and for 10-year periods, analyzing the evolution of precipitation in each decade separately.

CHAPTER II. GEOLOGICAL AND GEOGRAPHICAL CONDITIONS FORMATIONS FOR RIVER WATER RESOURCES IN CĂLIMAN MOUNTAINS

1. The role of geological condition in fthe formation and distribution of the river network from Căliman Mountains

The geological conditions of the Caliman Mountains, although seemingly simple, have a complex influence on the organization and evolution of the river network as well as the quantitative and qualitative characteristics of the water resources of the rivers.

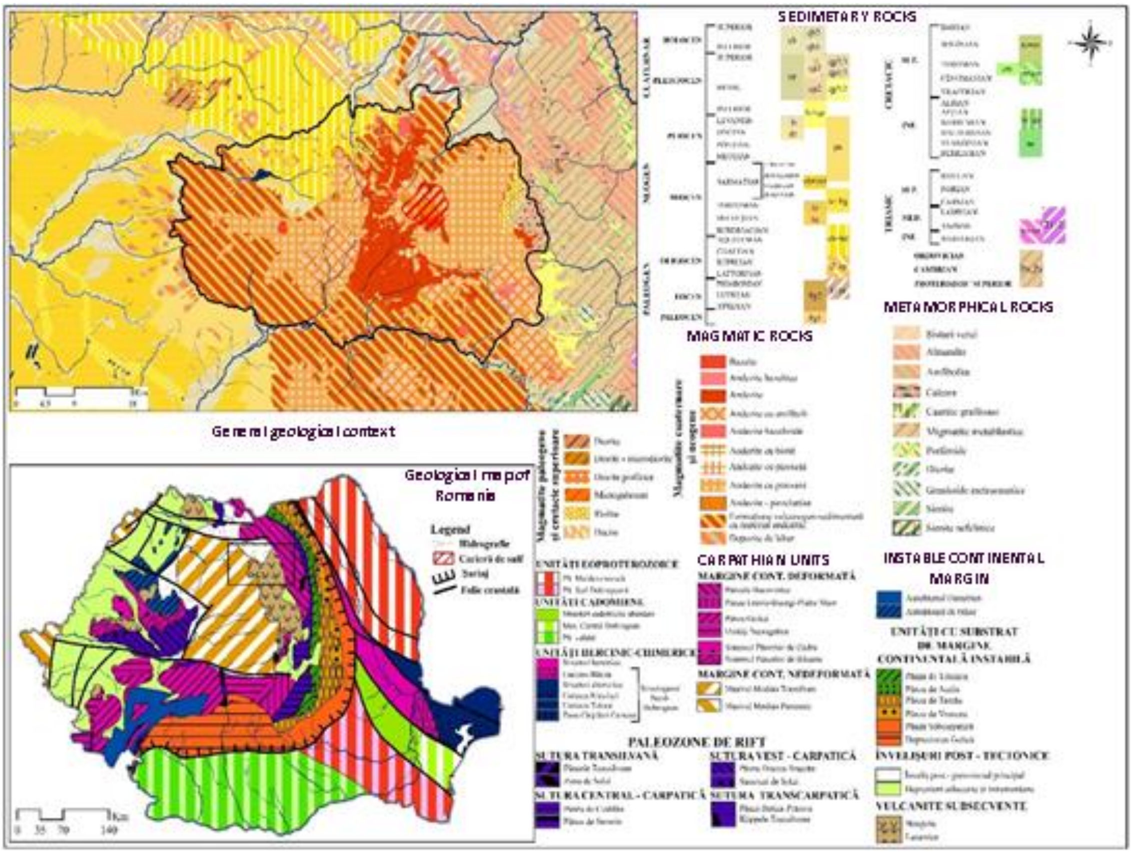

Fig. 5. Geological map of Romania and of Căliman Mountains

Compared to the Gurghiu and Harghita Mountains, the volcanic massifs in the Central Group of the Eastern Carpathians, the Caliman Mountains are distinguished by the large spread of the primary pyroclasts, which reach thicknesses of tens even hundreds of meters. Being strongly cemented, they are also noticeable in the morphology of the massif giving characteristic shapes of needles, corners as they appear on the Doisprezece Apostoli, Pietrele Roșii or Tihu peaks. Andesitic lava, especially pyroxenic, have great development especially in the eastern and western parts. As a result of the mechanical disaggregation process, which mainly affects the mountain area as a result of the thermal amplitudes, at the base of the slopes there have been accumulated, over time, train tracks.

2. The role of relief in river water flow in Căliman Mountains

The role of altitude in the distribution of water resources, in the three hydrographic basins belonging to Căliman (Mureș, Siret and Someș) can be observed by studying the organization of the hydrographic network in this sector. Thus, following the general legality, the hydrographic basins of the streams in the region are presented in an incipient form, weakly organized at high altitudes, and as the altitude decreases, the streams in the region will receive outputs that will make up their entire river basin. Due to this aspect, the volume of water transported on streams in the region increases as the altitude decreases.

Table 3. The percentage of each altitude interval in the three river basins

Altitude range (m)	Hydrographic basin						Total	
	Someș		Mureș		Siret			
	F (km²)	%	F (km²)	%	F (km²)	%	F (km²)	%
485 -600	0.00	0.00	5.44	0.01			5.45	0.34
601 - 700	2.94	0.89	24.90	0.03			27.84	1.76
702 - 800	18.50	5.63	64.04	0.08			82.54	5.21
801 - 900	37.67	11.47	90.16	0.12			127.83	8.07
901 - 1000	52.24	15.90	111.50	0.14	4.22	0.89	167.96	10.60
1001 - 1100	56.23	17.11	116.90	0.15	45.58	9.63	218.70	13.80
1101 - 1200	49.25	14.99	103.15	0.13	79.28	16.75	231.68	14.62
1201 - 1300	39.75	12.10	80.26	0.10	79.39	16.77	199.40	12.59
1301 - 1400	30.27	9.21	70.76	0.09	75.51	15.95	176.54	11.14
1401 - 1500	25.20	7.67	45.40	0.06	64.72	13.67	135.32	8.54
1501 - 1600	12.65	3.85	30.11	0.04	52.97	11.19	95.72	6.04
1601 - 1700	1.84	0.56	16.15	0.02	35.52	7.50	53.51	3.38
1701 -1800	1.19	0.36	12.80	0.02	20.58	4.35	34.57	2.18
1801 - 1900	0.66	0.20	7.68	0.01	10.20	2.15	18.53	1.17
1901 - 2000	0.16	0.05	2.45	0.00	4.86	1.03	7.46	0.47
2000 - 2100		0.00	0.52	0.00	0.64	0.13	1.16	0.07
Total	**328.55**	**100**	**782.22**	=	**473.46**	**100**	**1584.23**	**100**

The hydrographic basin of Mureș, as a stretch is the largest 782.22 km^2, and the smallest as a stretch is the hydrographic basin of Someș with an area of 328.55 km^2. The highest weight in terms of altitude is in the range 1101-1200m of 14.62% for the three component hydrographic basins (Table 3).

The Călimanului Plateau is located at a higher altitude (1300 - 1600 m) compared to the rest of the volcanic chain, being dominated by a huge dome, which rises to 2100 m. Its height and massiveness are maintained in the marginal areas. The narrow and deep valleys (400 - 600 m) are forested and there are seasonal settlements.

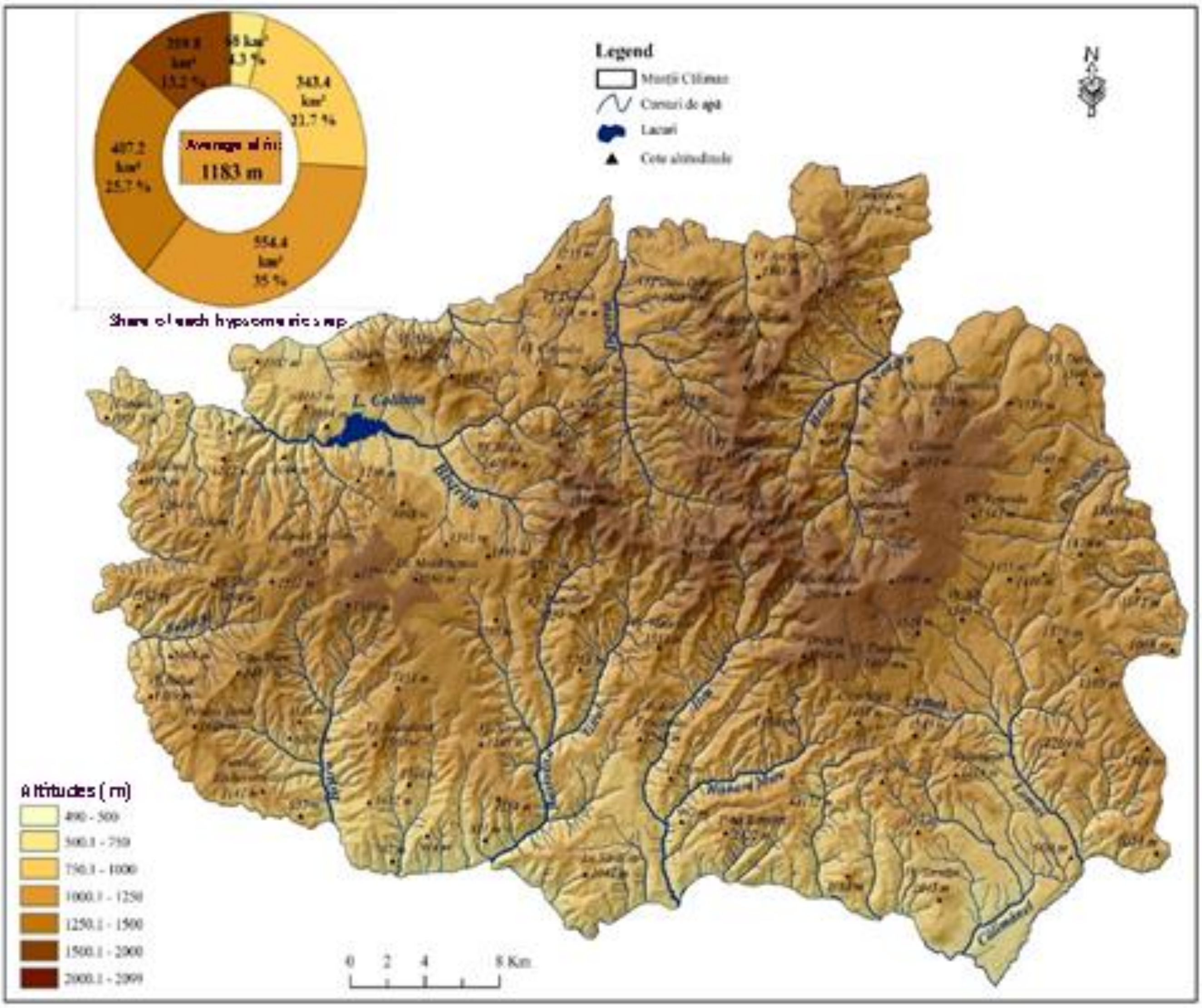

Fig.6. Hypsometric map of Căliman Mountains

Geodeclivity. The slope is one of the most important control factors for surface and underground liquid leakage (Fig. 7).

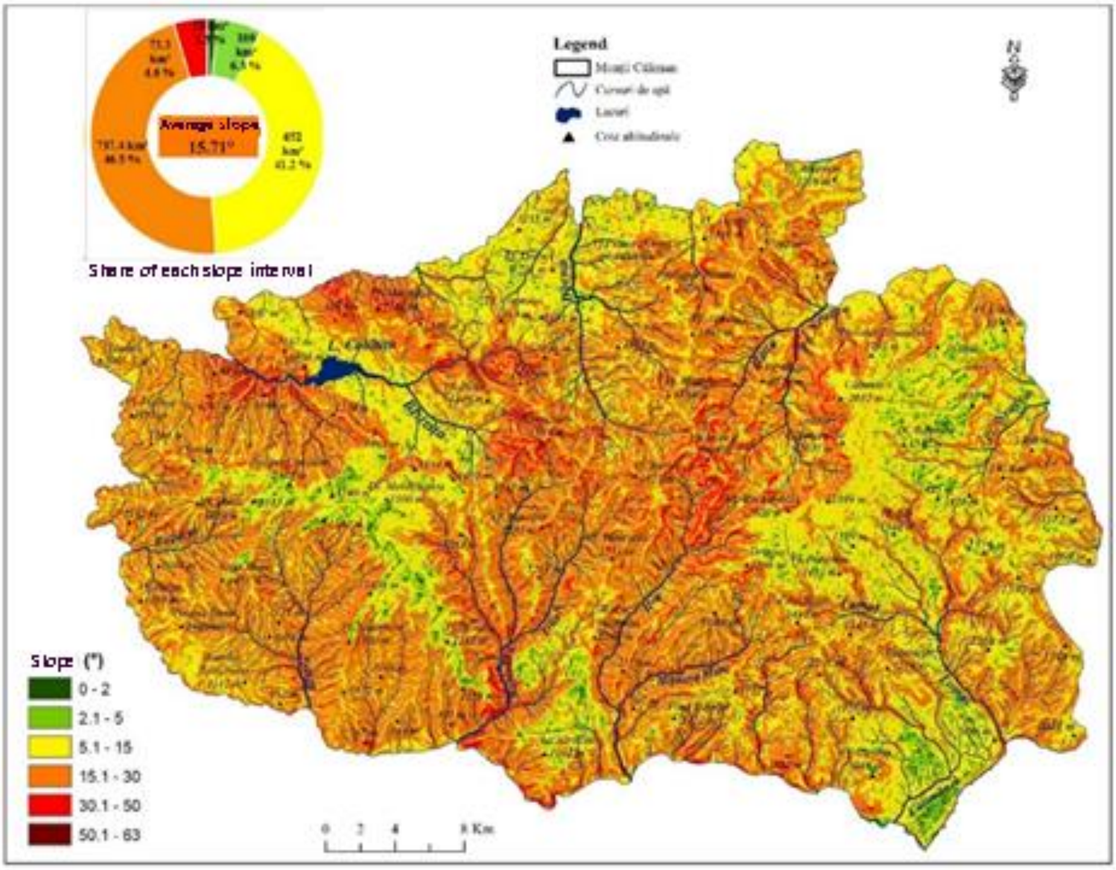

Fig. 7. Geodeclivity map of Căliman Mountains

Density of fragmentation. The analysis of the density of the fragmentation of the relief or the appreciation of the fragmentation in the surface of the relief, is done by calculating all the negative relief forms created by the geomorphological processes of erosion on a certain surface and their relation to it.

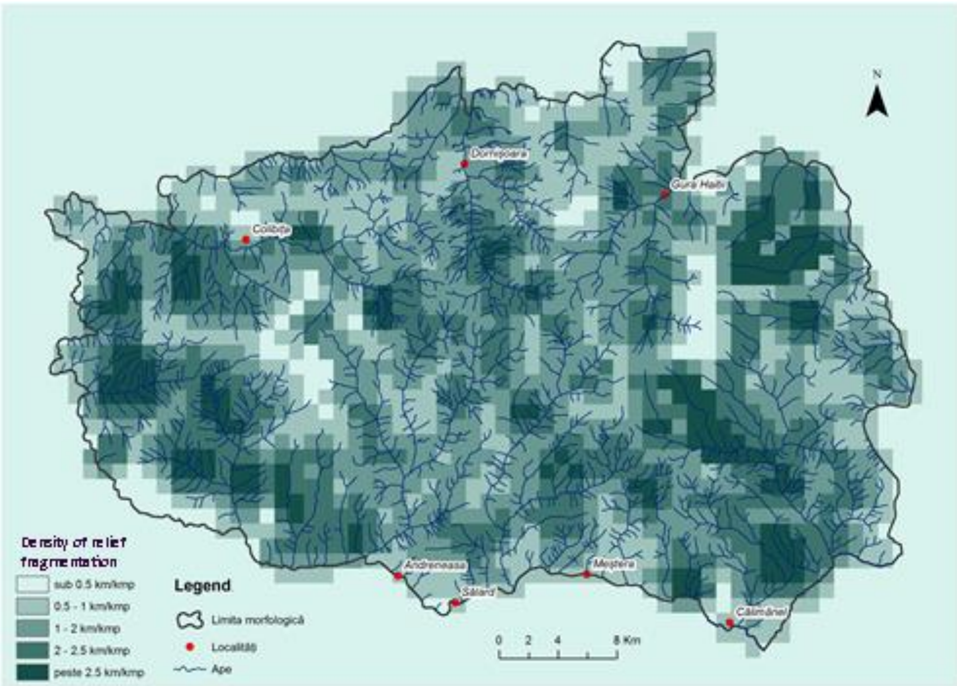

Fig. 8. Density of fragmentation

From the point of view of the depth of fragmentation, the studied area is subject to the laws that govern the mountain areas, namely the depth of fragmentation is reduced in the area of the valley, then increases on the slopes of the massif, and then decreases to its edge.

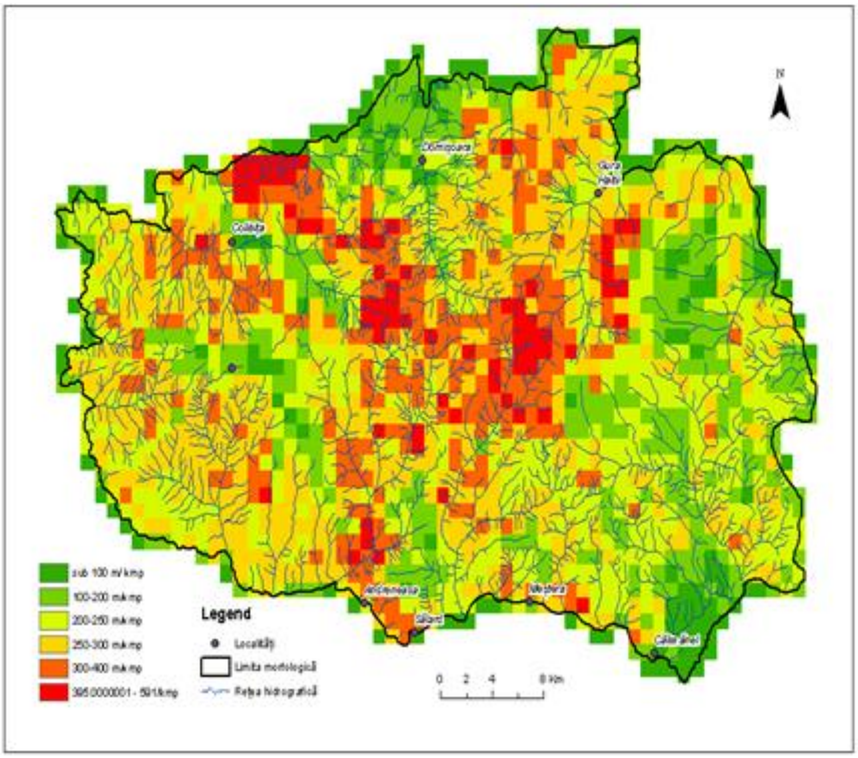

Fig. 9. Depth of fragmentation

The orientation of the slopes produces the differentiation of the duration of the solar radiation, together with the slope it generates different caloric regimes, which influenced the water resources quantitatively.

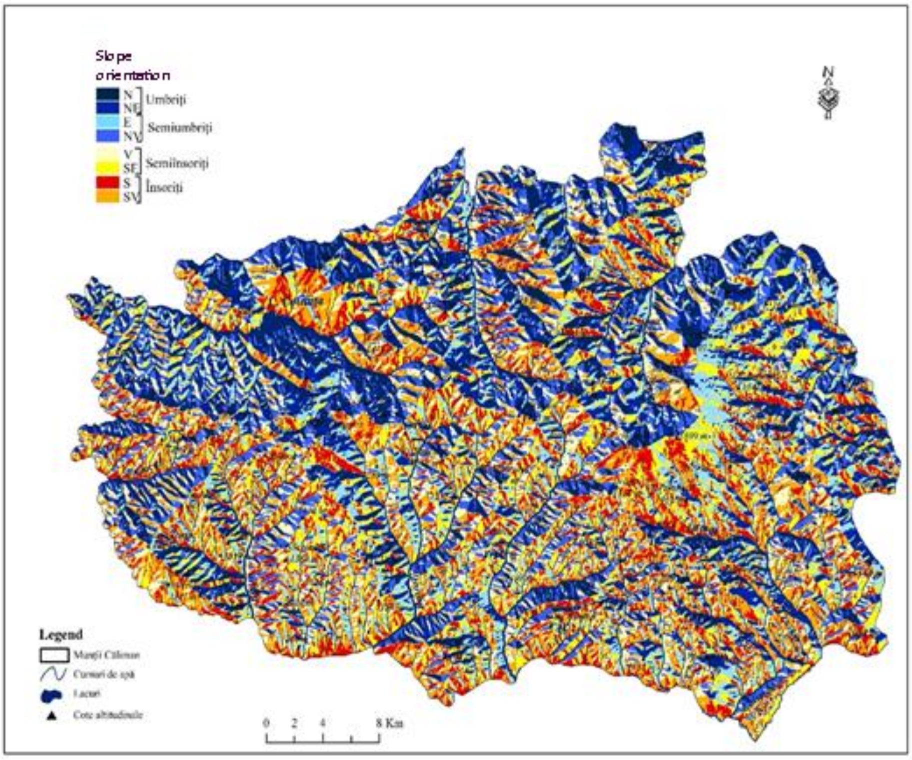

Fig. 10. The slopes exposition in Căliman Mountains

3. Climatic conditions and their role in the formation of river water resources from Căliman Mountains

The climate of the Caliman Mountains presents certain particularities directly involved in the formation and development of hydrological phenomena. The role of climate conditions is one of the most important factors influencing the annual runoff regime. The main factors under the incidence of the studied area impose the type of feeding of the rivers through the annual thermal regime, the precipitation and the thickness of the snow layer.

3.1 Genetic factors of the climate formation in the Căliman Mountains

The climatic factors represented by temperature, precipitation and snow layer thickness under the major influence of the relief represented by altitude, the exposure of the slopes and the density of fragmentation determine the water resources, the distribution and the water flow regime of the rivers belonging to the Căliman Mountains.

The oscillation of the average amount of precipitation in the three hydrographic basins that make up the Caliman Mountains under the influence of the relief can be observed by reducing the amount of precipitation from the west to the east of the Caliman Mountains.

3.2 The analysis of the main climatic elements

3.2.1 Air temperature

The analysis of the main climatic elements has a beneficial or restrictive influence through its values both on the phenomena and processes of the petrographic substrate, the relief, the soil, as well as the living kingdom (vegetation, fauna and human communities). Each component is specific to a climatic optimum beyond which the temperature can become restrictive by negative or positive values that exceed a certain limit.

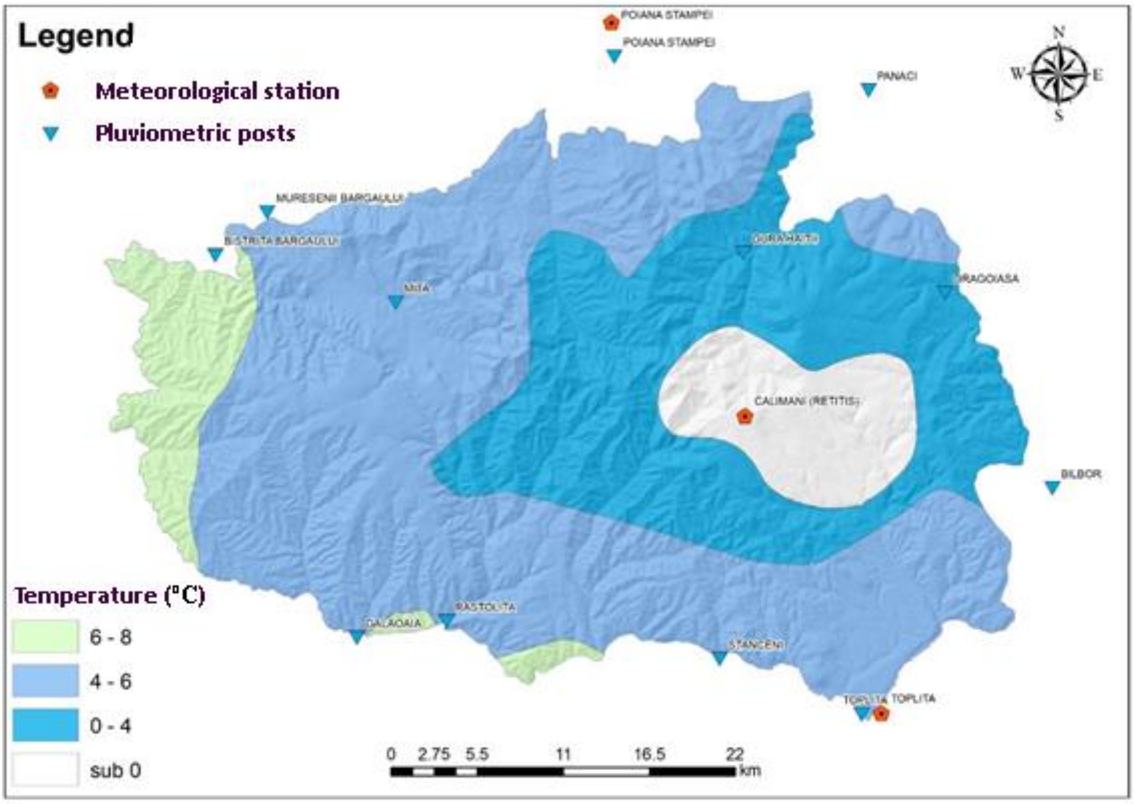

Fig. 11. The repartition of the multiannual average temperatures in Căliman Mountains

The distribution of the average multiannual temperatures (Fig. 11), was elaborated after the Climate of Romania, ANM 2008, and the Publishing House of the Romanian Academy Bucharest for the period 1961-2000.

From its general analysis, the character of a suitable climatic environment for the whole of the massif regardless of location and complexity. The lowest values are normal given the high mountain topographic situation with prolonged winters.

Table 4. Multiannual average temperatures

	Bistrița	**Poiana Stampei**	**Reţitiș**	**Toplița**
Average	8,31	5,27	3,53	6,24

The climate is typical of the mountain area, characterized by low temperatures, so the average multiannual temperatures range from 3.53ºC to 8.31ºC. At the weather station Reţitiș, the lowest multi-annual average temperature of the 4 weather stations is recorded, as this station is at an altitude of 2021 m.

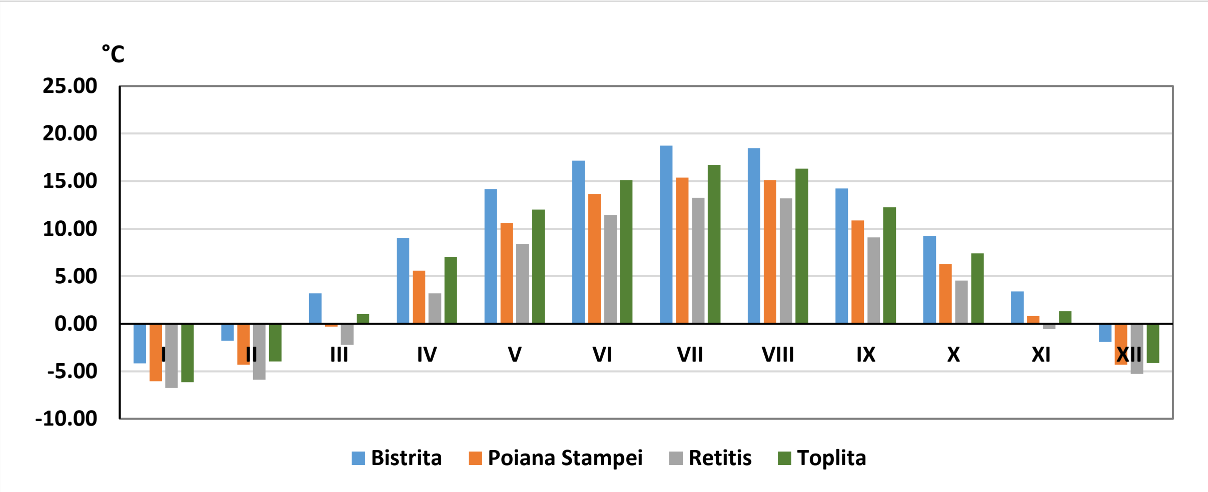

Fig. 12 Monthly regime of the air temperatures (1960-2010)

3.2.2 Rainfalls

Atmospheric precipitation comprises all the condensation and crystallization products of water vapor in the atmosphere, also called hydrometeors, which usually fall from the clouds and reach the surface of the earth in liquid, solid or both forms.

Atmospheric precipitation is the main climatic factor that directly influences the water resources of the Căliman Mountains.

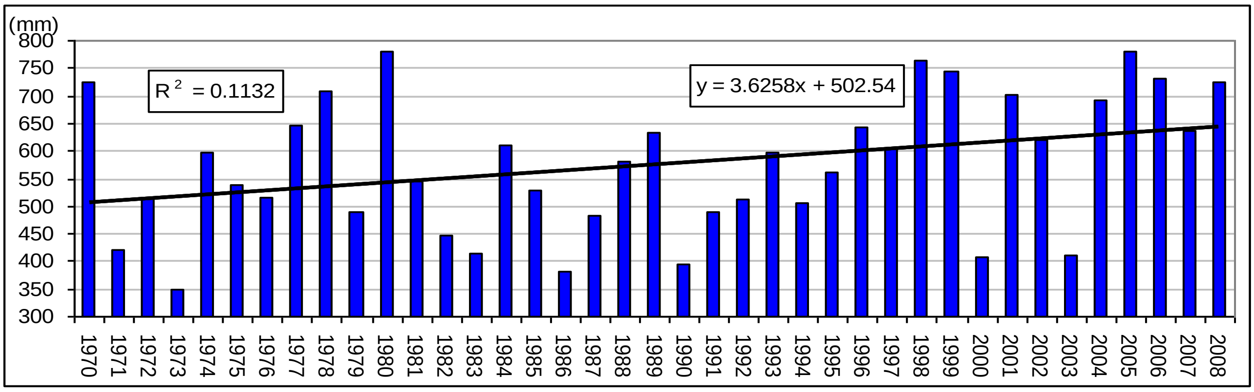

Fig. 13. The variation of annual rainfalls quantities at Toplița(1970-2008)

Table 5. The rainfalls trend in the interval 1961-2010

1961-2010	Bistrița	Poiana	Rețitiș	Toplița
ANUAL	0,24	0,18	0,18	2,01
Spring	0,59	0,35	-0,20	0,92
Summer	-0,68	-0,79	0,05	0,59
Autumn	0,93	0,99	1,42	2,21
Winter	0,84	-0,62	-1,07	0,10
February	0,44	-0,08	-0,79	0,23
July	0,66	-0,12	0,24	0,49

Trend of quantities of atmospheric precipitation over decades. Further we will analyze the trend of precipitation for the five decades included in the study period 1961-2010. These decades are: 1961-1970, 1971-1980, 1981-1990, 1991-2000, 2001-2010, the trend being calculated in mm / year.

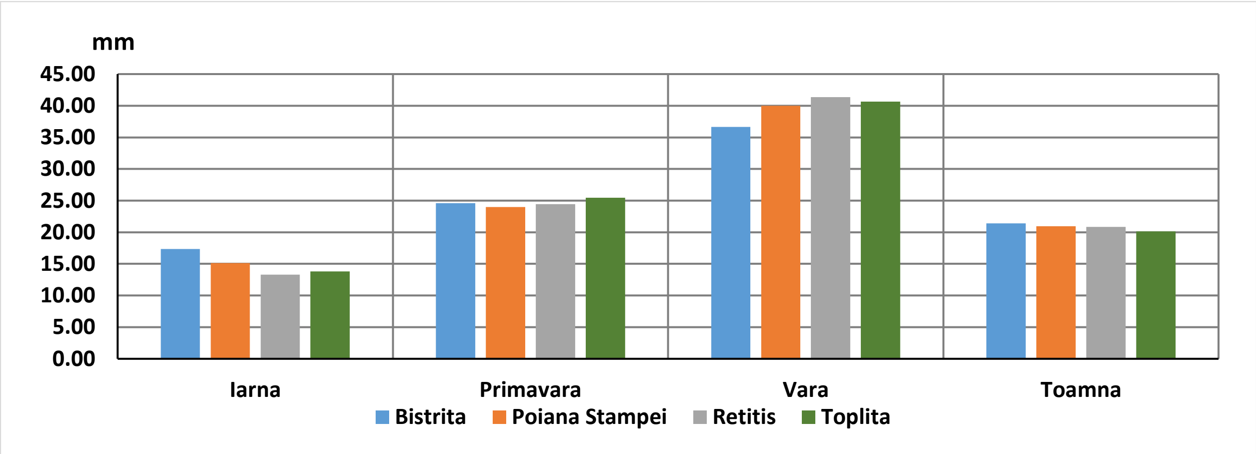

Fig. 14. The seasonal quantities of rainfalls (1961-2010)

Regarding the monthly regime of the atmospheric precipitation, analyzing the meteorological data between 1961-2010, a maximum is identified in the months of June-July and a minimum of the quantities of precipitation in the months of January-February.

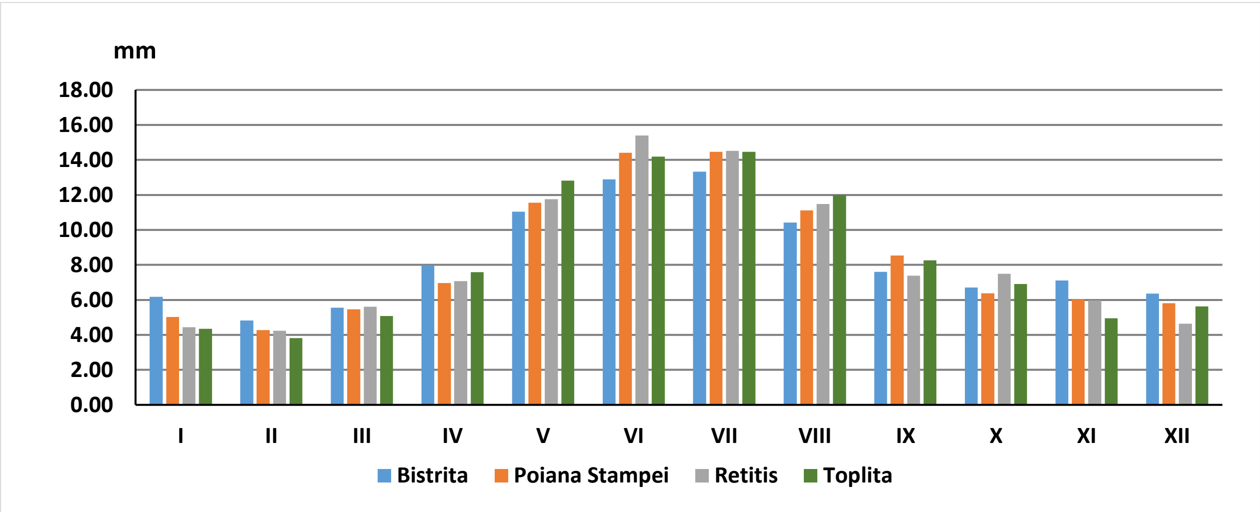

Fig. 15. The variation of monthly average rainfalls in the studied area (1961-2010)

3.2.3. Snow layer

The melting of the snow layer is one of the factors that influence the genesis of the spring-level floods along with the rich rainfall associated with the same season.

Of the four stations analyzed, the highest duration of snow layer maintenance on the surface of the terrain characterizes the high mountain area, where, according to the data provided by the weather stations, the snow layer stays on the surface for the longest period of the year, approximately nine months at the station Rețitiș.

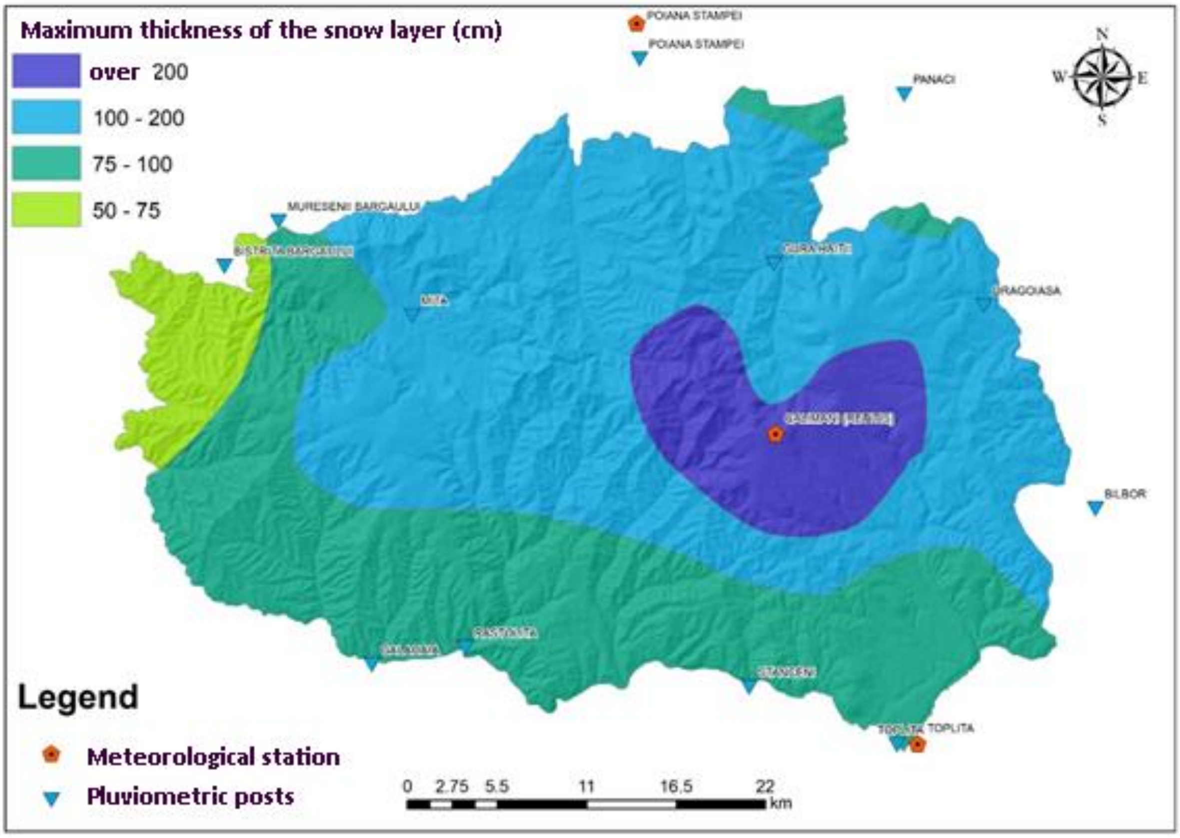

Fig. 16. The maximum thickness of the snow layer in the Căliman Mountains

The average thickness of the snow layer at the Retititis weather station can reach up to 90 cm, this station being at the highest altitude of the studied area.

Table 6. Seasonal values of the snow layer

Meteorological station	Winter	Spring	Summmer	Autumn
Bistrita	30,13	3,18	0,00	1,47
Poiana Stampei	66,30	17,27	0,00	5,08
Retitis	106,70	46,99	0,00	11,46
Toplita	39,87	7,32	0,00	3,21

4. Edaphic conditions and their role in the water flow process

The influence of soils on the hydrological balance consists in reducing the leakage values and increasing the evapotranspiration values in the aquifer regions. Luvisols are located in the lower area, at the ends of the study area.

Most of the soils in the mountain area of the studied area are mountain browns, forest acids in varying degrees of decomposition, and in the high area of the Călimanului spodosols due to the degree of massive afforestation, being, generally, little affected by erosion.

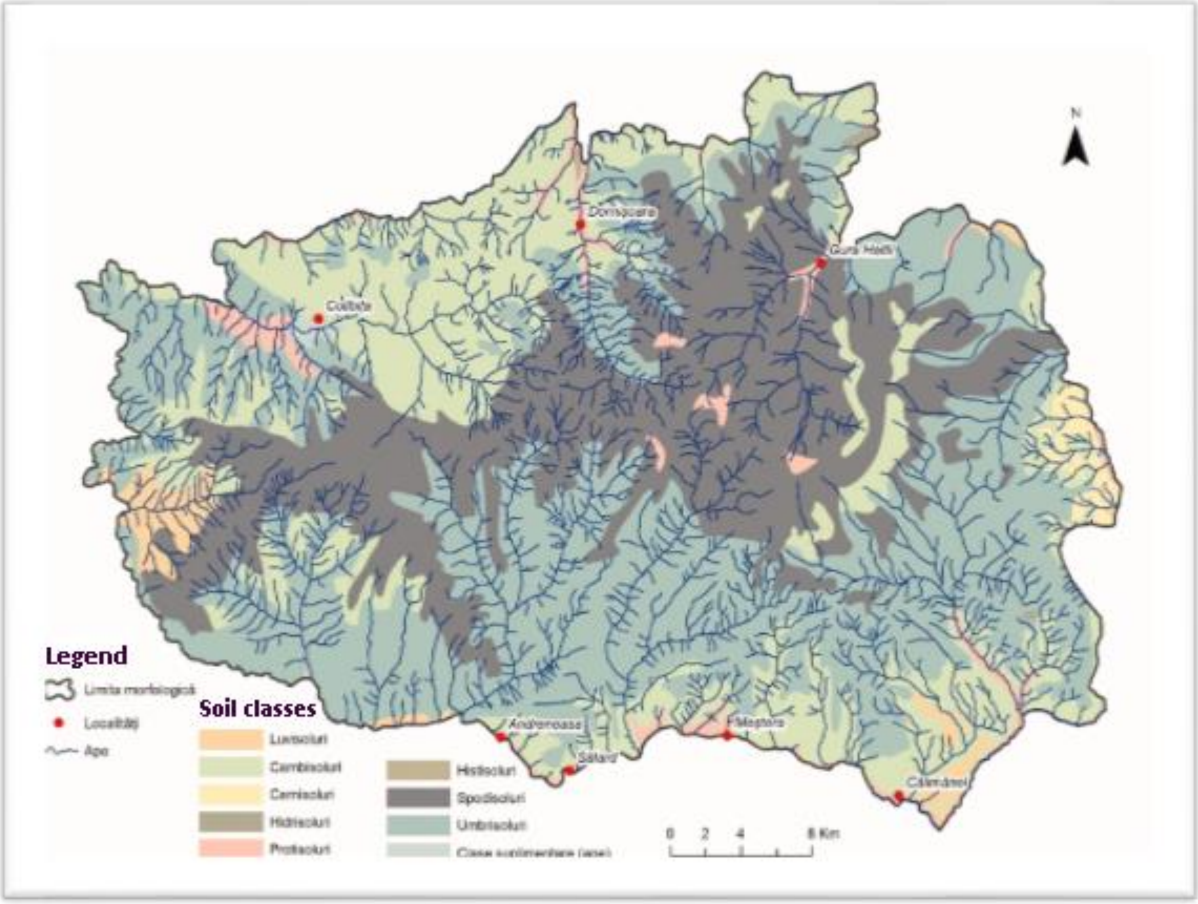

Fig. 17. The map of soils from Căliman Mountains

The influence of the edaphic carpet on the distribution of water resources and implicitly on the flow regime of the rivers in this sector is manifested by its characteristics: particle size, structure, degree of compaction.

The low permeability of the soils that characterize the mountain slopes of the area, is due to the high degree of saturation with water from the soil, this quantity of water being maintained for a prolonged period as the altitude increases and determines a rich underground supply.

5. The role of vegetation in the water flow process

The vegetation has different roles in the formation of river drainage. Thus, by increasing the capacity to infiltrate water into the soil, it helps to increase the amount of water stored in the underground water resources, helping to supply surface water during periods of minimal drainage (autumn, winter). By decreasing the insulation and the amount of water from the precipitation received by the soil, and by slowing down the process of melting the snow, the vegetation accentuates the infiltration at the expense of evaporation, contributing to maintaining soil moisture and decreasing the evaporation of water in the areas covered with vegetation.

The degree of vegetation coverage of the river basins in this sector is quite high, with forests being dominant. The degree of vegetation cover can influence the liquid flow of the rivers, in this case representing a factor that attenuates the speed and amplitude of the peaks of the flood.

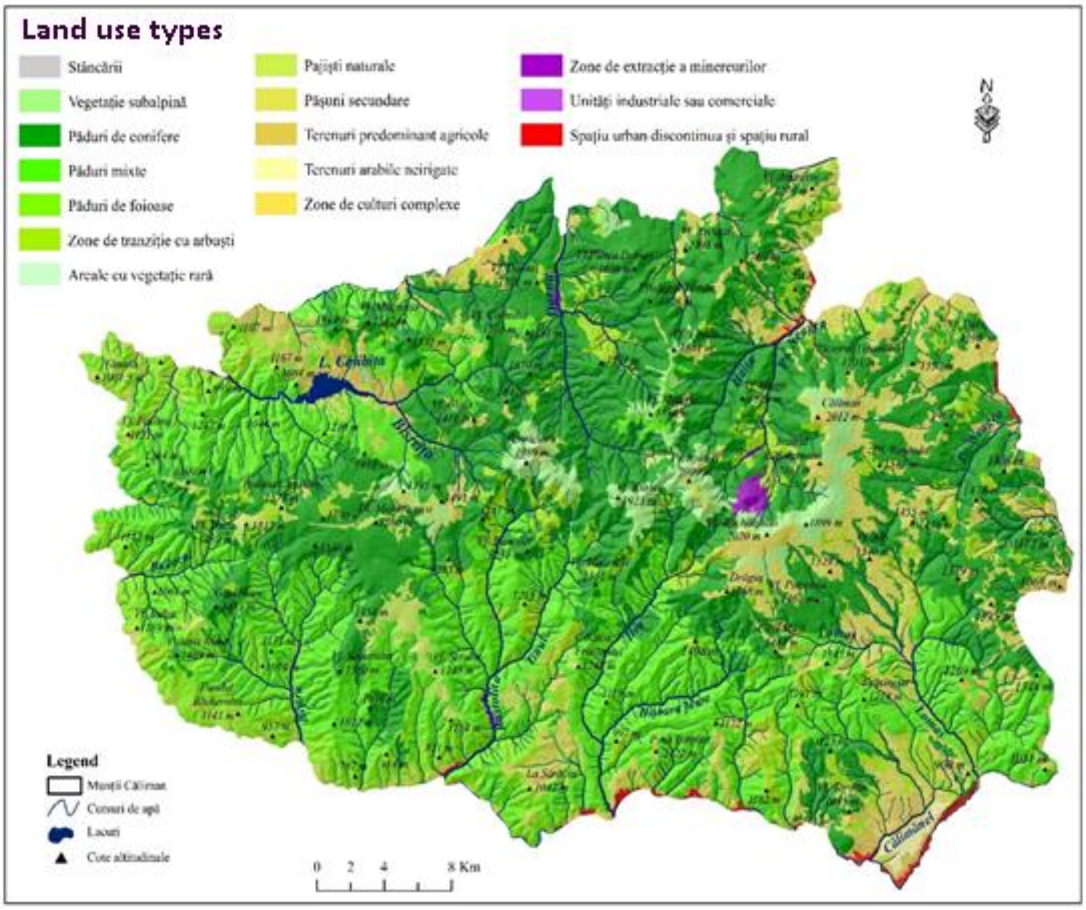

Fig. 18. The vegetation and the land use in Căliman Mountains

5. The influence of the anthropic factor on the conditions of formation of the water resources of the rivers in the Caliman Mountains

The Căliman Mountains represent a territorial ensemble characterized by a poor habitation, with the exception of the peripheral area of the massif, ie the Piedmont area.

Permanent or temporary dwellings through the confined space that they influence are only secondary to the influence of the river water drainage regime.

Regarding the space inhabited on the east and south sides, settlements are arranged almost parallel to the edges of the massif, being depressions of volcanic dam - Păltiniș, Dragoiasa, Glodu, Bilbor, Secu and Toplița and continuing in the northern part with Șaru Dornei, Coverca, Panaci, Neagra Șarului, Gura Haitii and Dornișoara. On the aisle of Mureș, in the southern part of the massif are found the localities Ciobotani, Stânceni, Meștera, Neagra, Lunca Bradului, Sălard, Andreneasa, Răstolița, Iod, Gălăoaia and Bistra Mureșului.

CHAPTER III. RIVER WATER RESOURCES IN CĂLIMAN MOUTAINS

1. Evaluation and spatial distribution of the water resources of the rivers of the Caliman Mountains

1.1 The average flow and water balance in the Caliman Mountains

The average flow is the main indicator of the scarcity of the water resources of the Căliman Mountains and it was determined as an average value of the daily, monthly and annual flows for the period 1950-2010.

From the category of knowledge systematization methods, the geographical classification was called, the grouping being carried out on three study periods, namely 1950-1967, 1950-2010 and 1970-2010 or the period of occurrence and unfolding of the event.

The volume of the average flow is a way of expressing the quantity of water drained through a certain section, obtaining as a product the value of the average flow and the time for which the value of the flow expressed in seconds is valid.

Table 7. Multiannual and seasonal average discharges (m^3/s)

Hydrological station	Annual	Spring	Summer	Autumn	Winter
Poiana Stampei	2,33	4,07	2,85	1,52	0,84
Dornisoara	0,68	1,24	0,76	0,44	0,26
Gura Negrii	4,20	6,66	5,40	2,87	1,88
Gura Haitii	0,90	1,49	1,15	0,60	0,37
Panaci	0,69	1,05	0,87	0,48	0,36
Tomnatec	0,65	0,83	0,87	0,54	0,36
Bilbor	0,96	1,49	1,22	0,68	0,45
Toplita	2,86	5,19	3,14	1,72	1,40
Rastolita	3,49	5,92	3,59	2,32	2,13
Bistra	2,39	3,89	2,36	1,65	1,65
Jelna	2,37	3,84	2,28	1,41	1,94
Mita	1,71	2,85	1,74	1,11	1,13
Bistrita Bargaului	3,57	5,50	3,61	2,41	2,75
Muresenii Bargaului	1,29	2,18	1,16	0,83	1,01

The trend of evolution of the annual average flow of rivers in the Căliman Mountains, the average annual flows of the main rivers is increasing.

The water balance evaluated at the level of the Caliman Mountains can be expressed on the basis of the multiannual average values of the main components as follows. The contribution includes 814 mm from atmospheric precipitation, of which 498 mm is consumed in the processes of formation of the global average flow, and 316 mm by evaotranspiration.

Underground drainage (Uo), like the other elements of the water balance, denotes a zone conditioned by the increase of the humidity and the intensity of the drainage from the axis of the main colors of the valley towards the interfluvial peaks. On the rivers in the Siret basin the values of the average underground runoff are lower, between 50 and 100 mm, while on the rivers in the Someş and Mureş basins, they are kept between 100 and 200 mm. The higher values are explained by the relatively abundant and constant contribution from the water sources accumulated in the more permeable sedimentary formations in these basins.

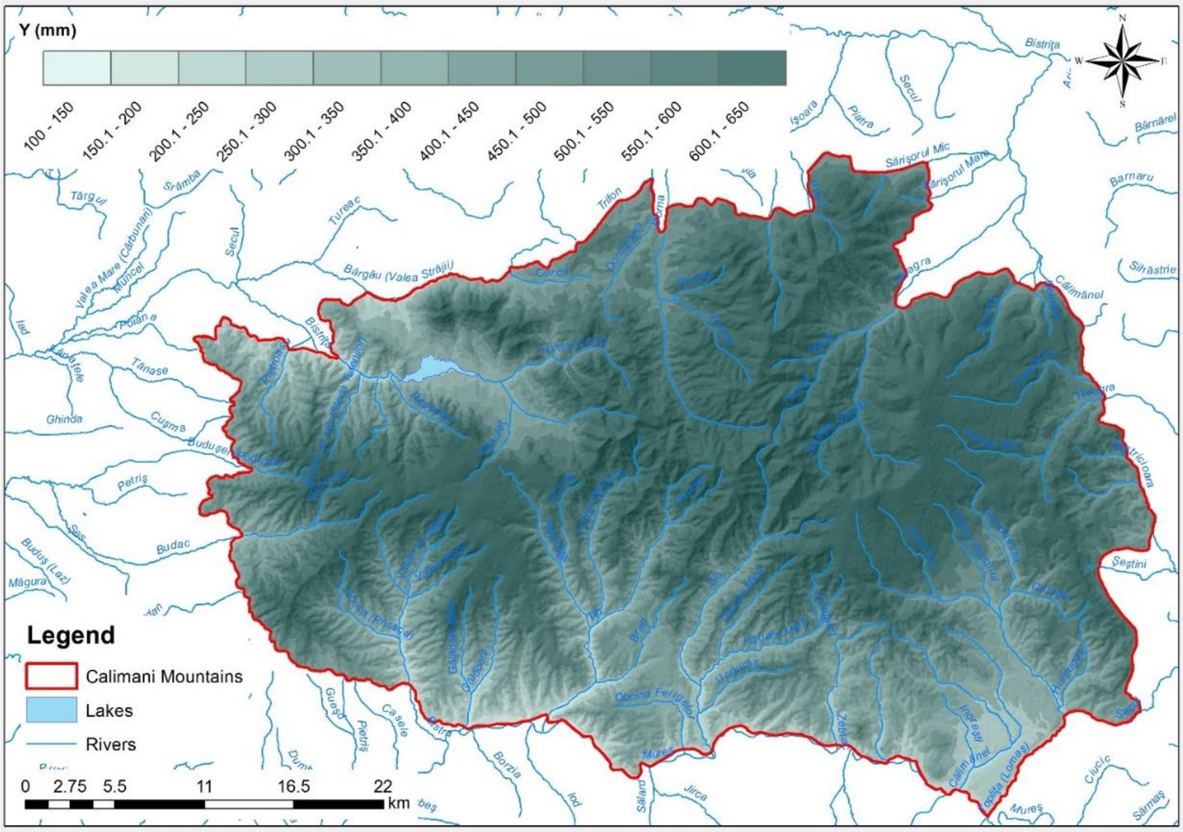

Fig. 19. Map of total average water flow

Underground drainage (Uo), like the other elements of the water balance, denotes a zone conditioned by the increase of the humidity and the intensity of the drainage from the axis of the main colors of the valley towards the interfluvial peaks. On the rivers in the Siret basin the values of the average underground runoff are lower, between 50 and 100 mm, while on the rivers in the Someş and Mureş basins, they are kept between 100 and 200 mm. The higher values are explained by the relatively abundant and constant contribution from the water sources accumulated in the more permeable sedimentary formations in these basins.

Evapotranspiration (Zo) determined as the difference between the average precipitation (Xo) and the global average leakage layer (Yo) depends on the potential of evaporation and the amount of moisture in the soil capable of evaporation. Thus, the calculated value of evapotranspiration is more indicative due to the lack of data from direct observations, which are influenced by local conditions specific to each subunit (degree of afforestation, soil types, exposure and inclination of slopes, etc.). Evapotranspiration values oscillate within restricted limits (mm). The values of evapotranspiration decrease with the others reaching the highest peaks of the Caliman Mountains at 200 mm.

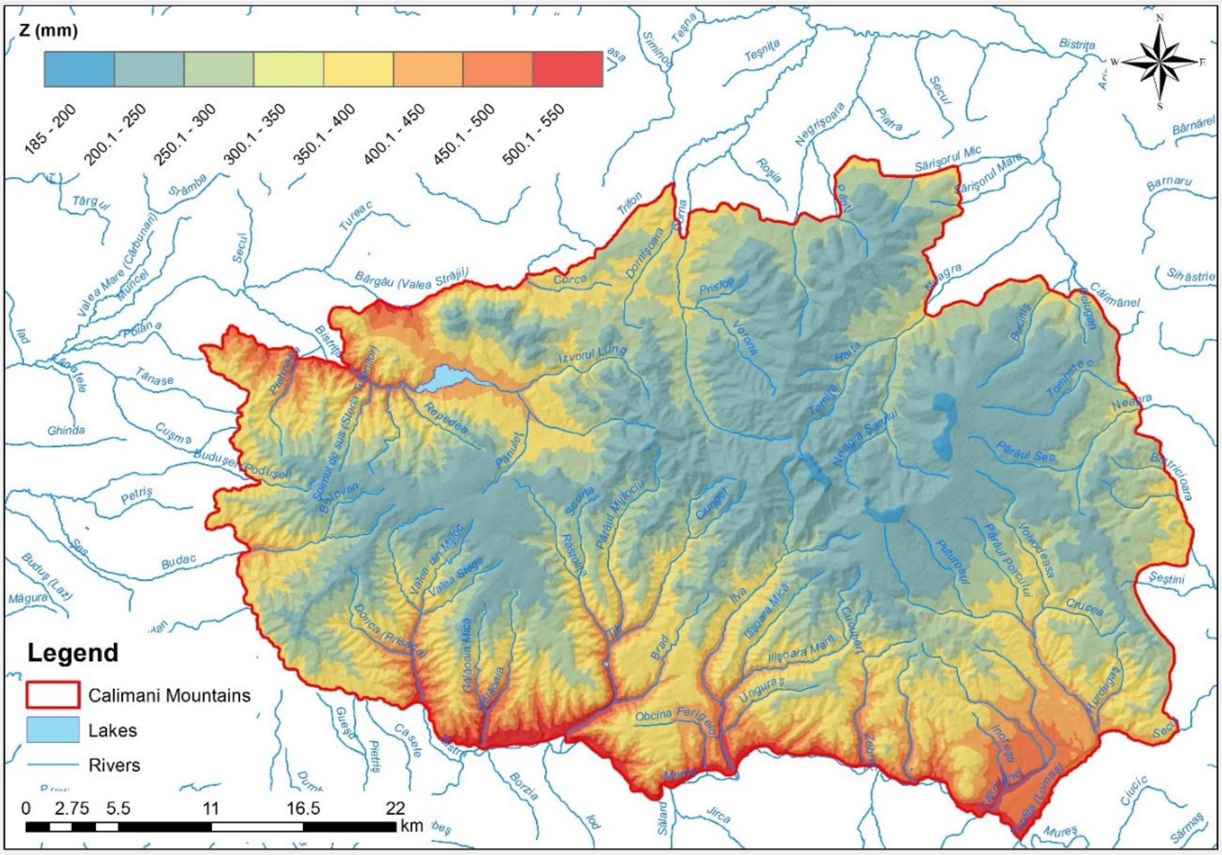

Fig. 20.. Evapotranspiration map.

1.2 Spatial distribution of water resources of rivers in the Caliman Mountains

The components of the water balance have an uneven distribution in time and space conditioned by the geographical particularities of the studied region.

The nuances that appear in the spatial distribution of precipitation and leakage are imposed in particular by the particularities of the air mass circulation and by the morphometric (especially altitude) and morphological characteristics of the relief. It is about the advection of the humid air masses from the west in the areas exposed in favor of their direction of movement, the catabatic movements felt on the eastern slope of the Căliman Mountains, respectively the increase, in general, of the altitude of the relief from west to east. , the valleys and the presence of depressive basins also have a role in the territorial nuance of the distribution of the components of the water balance by amplifying or attenuating the intensity of the rainfall processes.

1.2.1 The repartition of water resources by altitude steps

The analysis of the distribution of the multiannual mean quantities over the altitude intervals in the validity ranges of the relations X = f (Hm) shows well the spatial differences imposed by the law of altitudinal zonation.

Depending on the exposure of the relief to the advection of the humid air masses, the increase of the precipitation quantities depending on the altitude occurs differentially in the three areas of validity of the relations X = f (Hm) (Table 35).

The differences between the quantities of precipitation corresponding to the altitude ranges in the neighboring areas are maintained between 100 and 150 mm, and between the remote areas they reach over 200 mm, which denotes obvious contrasts in the distribution of the precipitation quantities imposed by the specific rainfall conditions of the analyzed areas. of precipitations at intervals of altitudes of the ranges of validity of the relations X + f (Hm) highlights the zonal character of distribution of the quantities of precipitations, conditioned by the altitude and the exposure of the relief with the circulation of the humid air masses in the western sector.

Tabel 8. Repartiţia cantităţilor medii multianuale de precipitaţii În arealele de valablitaate a relaţiilor X=f (H_m)

No. crt.	Altitude	Valability area		
		III	II	I
1.	492-500	500	620	740
2.	500-600	560	670.0	780.0
3.	600-700	600	705.0	820.0
4.	700-800	630	740.0	857.5
5.	800-900	668	770.0	887.5
6.	900-1000	693	795.0	912.5
7.	1000-1100	723	815.0	935.0
8.	1100-1200	748	835.0	952.5
9.	1200-1300	773	852.5	967.5
10.	1300-1400	790	867.5	980.0
11.	1400-1500	800	880.0	990.0
12.	1500-1600	810	890.0	995.0
13.	1600-1700	818	897.5	997.5
14.	1700-1800	823	902.5	1000.0
15.	1800-1900	825	907.5	1002.5
16.	1900-2000	825	910.0	1005.0
17.	2000-2100	833	930.0	1027.5

1.2.2 The repartition of water resources by hydrographic basins

Analyzing the spatial distribution of precipitation at the level of the main hydrographic basins, we notice quite obvious differentiations. Thus, the highest amounts of rainfall were determined for the Siret basin, and the lowest for the Mureş basin.

The water balance evaluated at the level of the Caliman Mountains can be expressed on the basis of the multiannual average values of the main components as follows. The contribution includes 814 mm from atmospheric precipitation, of which 498 mm is consumed in the processes of formation of the global average flow, and 316 mm by evaotranspiration.

From the global average leakage, 422 mm represents the surface leakage, and 106 mm the underground leakage. From this results the relatively low participation of the underground resources in the global soil dampening, which represents 57.2% of the rainfall, that is, 461 mm.

Table 9. The structure of the hydric balance in the main hydrographic basins from the Căliman Mountains.

River basins names	Elements of hydric balance (mm)					
	X_o	Y_o	S_o	Z_o	U_o	W_o
Somes	883.5	528.1	422.5	355.4	105.6	461
Mureș	786.2	440.8	352.6	345.4	88.2	433.6
Siret	811.6	574	459.2	237.6	114.8	352.4
Căliman Mountains	814	498.4	398.7	315.6	99.7	415.3

At the level of the studied region the average multiannual volume of water resulting from the total drainage was evaluated at 789 million m^3, which corresponds to an average layer of 498.4 mm. as in the case of precipitation, the spatial distribution of the volumes of water resulting from the global average flow is different, depending on the weight of the areas owned by each river basin.

Thus, the weight of the three basins in achieving the average multiannual volume of water resulting from the total runoff is different: the Somes basin participates with 22.2% in the total volume of runoff water, while the Mures basin with 43.8%, and of Siret with 34.0% .

1. Regimul de scurgere a apei râurilor din Munții Căliman

The water regime represents the legal change of the state of water resources over time, as a result of the influence of the geological factors, of which the climatic factors are highlighted as having the most important role. The flow regime can be defined by several values: the quantity of water drained annually, the rate of daily flows which implies the characterization of the leakage phases. We must not forget of course that the anthropic can play a very important role in the redistribution or balancing of the distribution of water resources during the year. The way in which the main power sources are combined is reflected in the distribution of the leak during the year.

The distribution of the flow during the year largely determines the economic value of the waters. The more balanced the flow regime of the watercourses, the more efficient they can be used. The way in which the main power sources are combined is reflected in the distribution of the leak during the year. In this study, the data from 14 hydrometric stations for the period 1950-2010 were used regarding the water flow regime of the mentioned region.

1.1 Regimul scurgerii anotimpuale

In the regime of the seasonal flow, the variation of the flow in each season is analyzed, the weight and the influence that the flow has. There are quite significant territorial contrasts between the three large basins that develop in the Căliman Mountains.

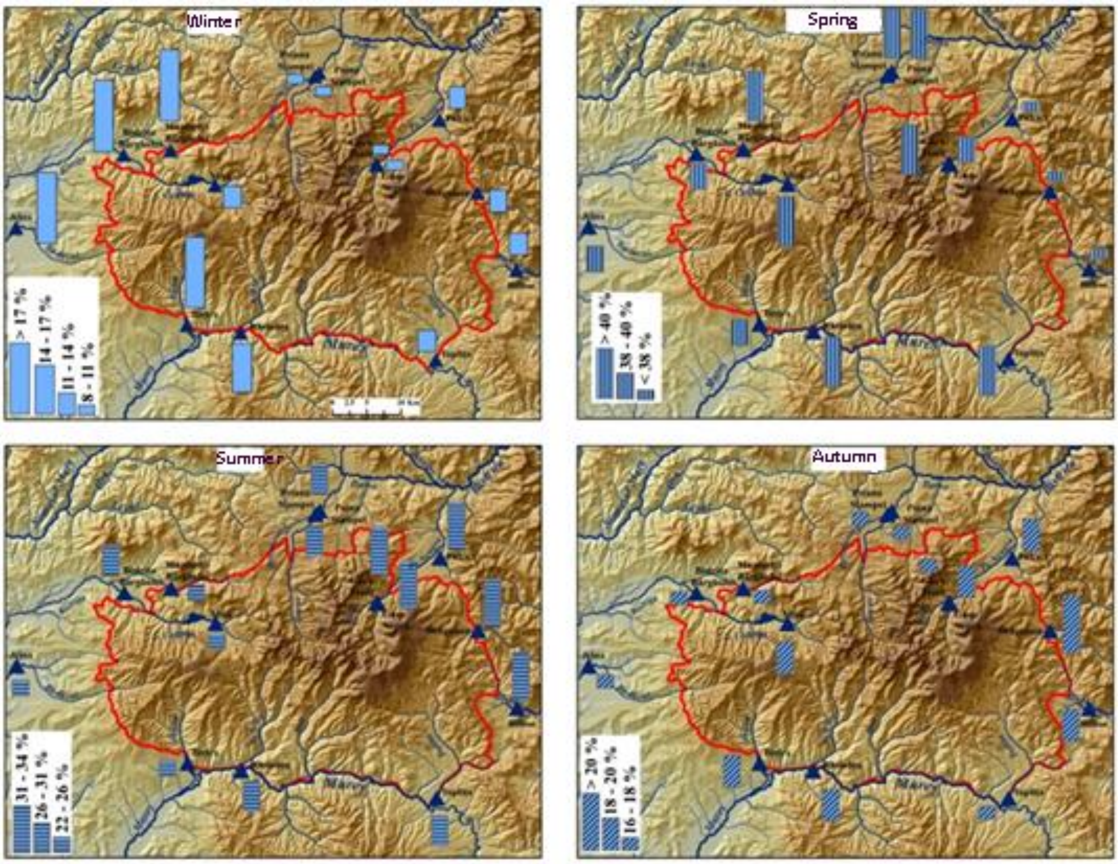

Fig. 21. Ponderea scurgerii anotimpuale

Table 10. The values of seasonal water flow (%) at the hydric stations from theCăliman Mountains for the period 1950-2010

Hydrometric station	Winter	Spring	Summer	Autumn
Poiana Stampei	*9,06*	**43,88**	30,67	16,38
Dornișoara	*9,72*	**46,03**	28,03	16,22
Gura Negrii	*11,18*	**39,64**	32,12	17,06
Gura Haitii	*10,15*	**41,47**	31,80	16,58
Panaci	*13,10*	**37,95**	31,55	17,40
Drăgoiasa	*13,87*	31,89	**33,43**	20,81
Bilbor	*11,70*	**38,84**	31,68	17,79
Toplița	*12,20*	**45,31**	27,45	15,04
Rastolita	*15,25*	**42,41**	25,75	16,59
Bistra	*17,26*	**40,70**	24,74	17,30
Jelna	20,50	**40,56**	24,06	*14,87*
Mița	16,51	**41,72**	25,54	*16,24*
Bistrita Bârgăului	19,28	**38,54**	25,27	*16,91*
Muresenii Bârgăului	19,58	**42,09**	22,37	*15,96*

The maximum and minimum deviations of the water flow. In the case of winter runoff, the highest positive deviations at the stations in the study area were recorded in three years: 1957, 1958 and 2010 (Table 10), the highest values being recorded in 2010, when they were reached deviations of + 348.97% at Dornișoara station and + 215.48% at Toplița station. These deviations were due to very high air temperatures, which caused snow melts, accompanied by significant precipitation.

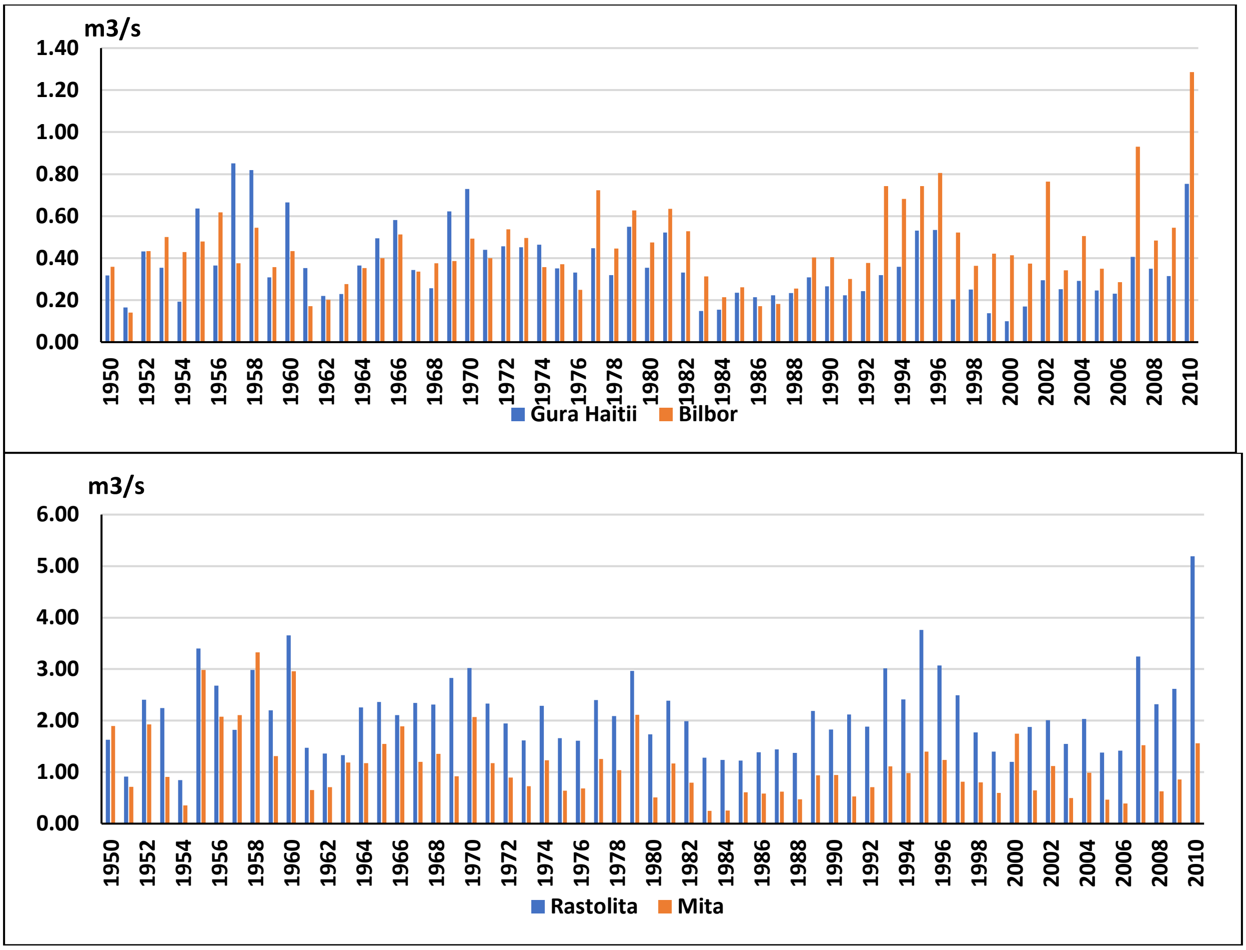

Fig. 22. Variația în profil multianual a scurgerii de iarnă la stațiile hidrometrice din zona de studiu

2.2 The monthly water flow regime

From the distribution of the average monthly flow during the year, we observe quite significant territorial differences generated by the climatic factors. Thus, on the rivers in the western part of the Căliman Mountains where the melting of snow occurs earlier, due to the lower altitude of the relief over the other mountainous areas, a maximum is highlighted in April (Table 11). In contrast, on the rivers in the northern part with basins developed in the upper part of the Caliman Mountains, the maximum percentage was reported in April.

The territorial differences are also highlighted by the analysis of the distribution of the average leakage of each month. Thus, in January the precipitations almost exclusively fell in solid form and the unfavorable conditions for their melting determine reduced values of the leak, which represents between 2.7% (Gura Haiti) and 5.7% (Jelna) of the average annual volume. Quite obvious contrasts exist between the western and northern rivers of the Caliman Mountains.

Table 11. Repartition of the monthly water flow regime (% from the average flow)

Hydrometric station	**I**	**II**	**III**	**IV**	**V**	**VI**	**VII**	**VIII**	**IX**	**X**	**XI**	**XII**
Bilbor	3.3	3.3	8.6	16.1	13.1	11.9	11.1	8.7	7.1	6.2	5.7	5
Bistra	5.4	5.6	10.2	16.8	12.5	10	8.1	6.0	6.0	6.1	6.7	6.6
Bistriţa B.	5.3	5.8	9.7	15.6	13.2	10.7	8.9	6.4	6.4	5.7	5.9	6.5
Dragoiasa	4.2	3.9	5.3	11.6	14.2	12.6	11.2	9.8	8.4	7.2	6.4	5.1
Gura Haiti	2.7	2.4	4.2	14.5	22.3	13.6	11	7.8	7.2	5.6	4.9	3.8
Gura Negri	3.4	3	6.4	14.3	17.6	13.5	10.8	8.2	7.4	5.8	5.2	4.3
Jelna	5.7	6.6	10.7	15.0	13.3	11.4	9.8	4.2	4.8	5.4	6.2	6.9
Miţa	4	4.4	9	18.2	15.9	10.5	8.7	6	6.5	5.8	5.8	5.2
Mureşenii B.	5.3	6.2	13.2	17.9	11.2	9.7	7.9	4.5	5.4	5.7	6.5	6.6
Panaci	4.2	3.9	7.9	13.3	14.8	12.6	10.9	8.5	7.1	6	5.8	5
Poiana S.Dorna	2.7	2.3	6.2	17	19.5	12.6	10.3	7.3	6.7	5.8	5.3	4.3
Poiana S.Dornişoara	2.9	2.4	8.6	21	16.1	10.9	9.4	6.5	6.3	5.6	5.4	4.8
Răstoliţa	4.7	4.5	8.8	17.7	14.3	11	8.6	6.3	6.1	5.9	6.1	5.9
Topliţa	3.4	3.4	8.2	18.8	16.5	11.8	9.7	7.0	5.9	5.3	5.2	4.7

The territorial differences are also highlighted by the analysis of the distribution of the average leakage of each month. Thus, in January the precipitations almost exclusively fell in solid form and the unfavorable conditions for their melting determine reduced values of the leak, which represents between 2.7% (Gura Haiti) and 5.7% (Jelna) of the average annual volume. Quite obvious contrasts exist between the western and northern rivers of the Caliman Mountains. In February, there was an increase in volumes that were lower compared to the previous month, higher (6.6%) in Jelna and the lowest (2.3%) in the Poiana Stampei station on the Dorna river.

In March, April and May, the richest flow of the year is achieved. Thus, on the northern and eastern rivers, the average March flow represents between 4.2% and 13.2% of the annual volume. In the summer months and the beginning of autumn the drastic reduction of precipitation amounts, the depletion of the underground reserves and the high values of evapotranspiration are the causes that diminish the values of the water flow of the rivers. The gradual decrease of the run volumes becomes more pronounced in August and September, when most rivers have the lowest monthly average flow, which represents between 3.9% and 4.9% of the annual volume (Table 11).

From November there is a slight increase in the flow generated by the intensification of autumn rains. The average flow from this month contributes between 4.9% and 6.5% to the average annual volume. With the increase of the precipitation quantities, an increase of the monthly flow is observed until December, after which there is an obvious decrease in the months of January and February, when on the rivers with hydrographic basins developed on the higher relief steps, over 1000 m, it is realized the lowest percentages of the leak due to the negative temperatures, which cause the water to remain more in solid form. Thus, the Haita river produces the lowest monthly flow that occurred in January (2.7%) and the highest was recorded in April (21%) at the Poiana Stampei station on the Dornișoara river.

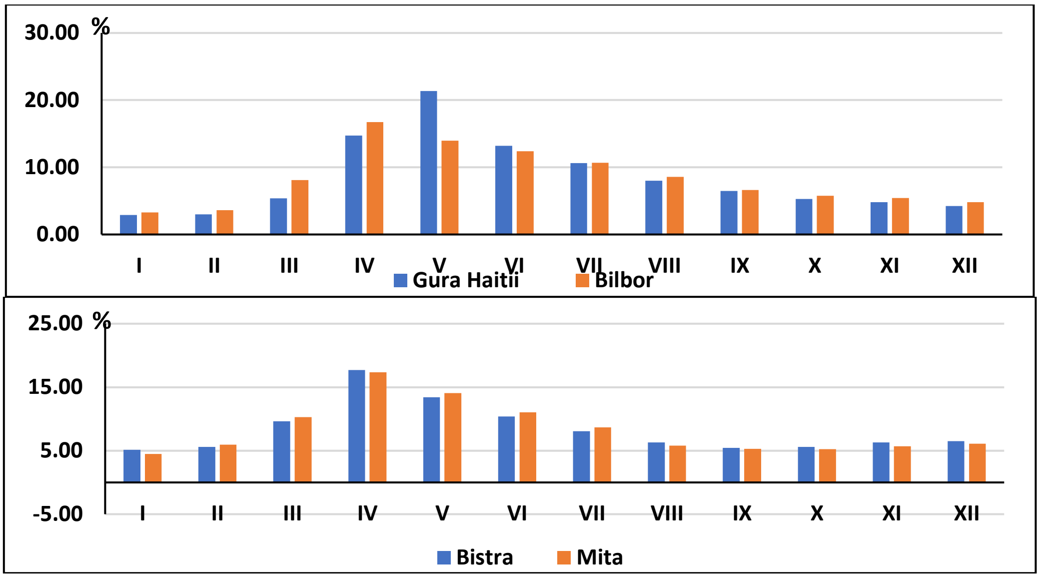

Fig. 23 Values of the monthly water flow at the main 4 hydric stations

Thus, several types of distribution at the monthly level were highlighted, highlighting type IV, V / I, II, specifically at two stations in the northern part of the group (Poiana Stampei and Dornișoara), respectively those located in the part of south and south-east of the studied area. The second type by weight is the V, IV / II, I, specific for the other stations in the northern part of the studied group. A type of transition between the two types is recorded at Panaci (V, IV / I, II).

The stations in the western part of the massif have different types, due to the increase of the frequency of the months with poor weight of the drain during the autumn, under the influence of the western climate, which causes an increase of the leak in the winter months. Thus, although the months with the highest flow are IV and V, the poorest months show variations from one station to another (Table 11).

Table 11. The richest months, respectively the poorest in water flow, and the water flow distribution types in the Căliman Mountains

Hydrometric Station	**The months with the highest river water flow (cases) and their frequencies (%)**				**The months with the lowest river water flow (cases) and their frequencies (%)**			
	First month	**%**	**Second month**	**%**	**First month**	**%**	**Second month**	**%**
Poiana Stampei	IV	47,5	V	42,6	I	36,1	II	32,8
Dornișoara	IV	55,7	V	36,1	I	32,8	II	32,8
Gura Negrii	V	37,7	IV	29,5	II	36,1	I	29,5
Gura Haitii	V	50,8	IV	26,2	II	34,4	I	31,1
Panaci	V	32,8	IV	31,1	I	37,7	II	34,4
Drăgoiasa	V	36,1	VI	23	II	44,3	I	32,8
Bilbor	IV	47,5	V	42,6	I	41,0	II	32,8
Toplița	IV	50,8	V	44,3	I	34,4	II	29,5
Răstolița	IV	63,9	V	39,3	I	36,1	II	23,0
Bistra	IV	67,2	V	49,2	I	34,4	II	29,5
Jelna	IV	47,5	V	18,0	X	19,7	IX	19,7
Mița	IV	45,9	V	29,5	I	31,1	X	22,9
Bistrița Bârgăului	IV	47,5	V	27,9	X	19,7	I	18,1
Mureșeni Bârgăului	IV	37,7	III	31,1	IX	19,7	X	29,5

2.3 Characteristic periods of the diurnal water flow regime

The characterization of the daily regime of the leak is made with the help of the type hydrograph based on the most frequent sizes, occurrence dates and durations of the regime phases materialized by the big spring waters, the small summer waters, the autumn floods, the small winter waters and the floods in winter, the typical hydrograph containing for each phase of the regime the external limits of variation of the respective size as well as their characteristic production data.

If the analysis of the superposed hydrograph of the 4 stations can be observed some similarity especially with regard to the periods during a year with low and high water. From the above hydrograph there are two peaks of the great periods, namely the spring in April-May due to the fact that this station is in the south-east of the Caliman Massif and the melting of the snow occurs later in the spring. Another peak can be observed in December at the Mița station on the western side of the Caliman Massif, due to the exposure on the side of the massif but also the low altitude in accordance with the other hydrometric stations.

The effect of the climatic factors cannot be assessed quantitatively using the standard hydrograph, so that the assessment of the climatic factors on the leak is used the hydrograph of a particular year called the characteristic average year hydrograph. The hydrograph of the characteristic average year has the variation similar to that of the typical hydrograph, as well as the annual and seasonal volumes close to the multiannual values.

2.3.1 Periods of high flow (high water and floods)

High flow periods represent the time interval during which the average flows are above the multiannual average values and are classified in the literature as periods of high water and floods. High water periods represent slow increases in river flows and maintain them at high rates for a period that can vary between a few days and in exceptional cases a few weeks or months. This phenomenon is due to the slow melting of the snow layer existing in the Căliman Mountains during the spring period.

The genesis of the floods from the Caliman Mountains is of a rainfall and rainfall level in the higher areas.

Floods can be characterized by the shape, genetic, temporal and spatial parameters, which can help prevent the strong effects produced by the floods on the inhabited area that affects them (Sorocovschi, 2017).

Table 12. Frecvența viiturilor din arealul studiat

River	Hydrometric station	No. of years	No. of floods/station	Period
Dorna	**Poiana Stampei**	**31**	55	1973-2003
Dornisoara	**Poiana Stampei**	**18**	36	1986-2003
Neagra	**Gura Negrii**	**31**	56	1973-2003
Haita	**Gura Haitii**	**22**	43	1982-2003
Neagra	**Dragoiasa**	**14**	28	1990-2003
Sarisor	**Panaci**	**18**	38	1986-2003
Toplita	**Toplita**	**10**	23	1980-1989
Rastolita	**Rastolita**	**10**	20	1980-1989
Bistra	**Bistra**	**31**	63	1980-2010
Bistricioara	**Bilbor**	**27**	57	1977-2003
Dragoiasa	**Tomnatec**	**31**	60	1973-2003
Mita	**Bistrita**	**27**	51	1983-2010

From the point of view of the form, the floods produced in the study basin present, in more than half of the individual cases, the highest values being registered on the tributaries, with 90% at the Bistra station. The compound floods appear mainly on the main course, reaching 36% at Bistrița station, due to the multitude of minor tributaries that the main course receives.

From the point of view of the genesis, the flood waves, which appear within a river basin, are strongly influenced by the amounts of precipitation dropped in the basin before and during the production of the floodwaters, as well as by the high temperatures that cause the sudden melting of the snow layer.

The frequency can be analyzed from the point of view of the multiannual distribution by seasons and months of the floods. The monthly frequency of the normal floods at the river stations in the Caliman Mountains shows that most floods occur in the months of April-May-June. The next months by weight are July and August, with higher values. This shows that spring floods are strongly delayed, and snowfalls have no intensities that influence the flow.

The duration of the floods shows their degree of danger. The faster a flood occurs, the shorter the warning time of the affected population, and the preventive measures that can be taken immediately before production and during the flood are much less (Table 13).

Table 13. The monthy frequency of the normal floods of the rivers from the Căliman Mountains

River	Station	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Dorna	**Poiana Stampei**	0.00	0.00	1.82	12.73	18.18	20.00	18.18	14.55	7.27	5.45	1.82	0.00
Dornisoara	**Poiana Stampei**	0.00	0.00	2.78	5.56	11.11	22.22	19.44	11.11	16.67	8.33	2.78	0.00
Neagra	**Gura Negrii**	0.00	0.00	1.79	14.29	14.29	21.43	16.07	10.71	14.29	5.36	1.79	0.00
Haita	**Gura Haitii**	0.00	0.00	0.00	18.60	18.60	20.93	20.93	4.65	11.63	2.33	2.33	0.00
Neagra	**Dragoiasa**	0.00	0.00	0.00	7.41	7.41	22.22	22.22	11.11	22.22	7.41	0.00	0.00
Sarisor	**Panaci**	0.00	0.00	8.11	8.11	18.92	18.92	21.62	8.11	13.51	2.70	0.00	0.00
Toplita	**Toplita**	0.00	0.00	9.52	28.57	28.57	14.29	14.29	4.76	0.00	0.00	0.00	0.00
Rastolita	**Rastolita**	0.00	0.00	10.00	30.00	20.00	20.00	15.00	5.00	0.00	0.00	0.00	0.00
Bistricioara	**Bilbor**	0.00	0.00	5.26	15.79	19.30	15.79	19.30	12.28	10.53	1.75	0.00	0.00
Dragoiasa	**Tomnatec**	0.00	0.00	0.00	8.33	13.33	26.67	18.33	16.67	15.00	1.67	0.00	0.00
Bistra	**Bistra**	1.59	1.59	7.94	20.63	12.70	7.94	12.70	7.94	6.35	9.52	3.17	7.94
Mita	**Bistrita**	9.80	1.96	13.73	25.49	13.73	9.80	7.84	1.96	5.88	3.92	1.96	3.92

The smaller the watercourses and the smaller surface area, the shorter the total time, in the Bistra and Răstolița rivers. Most cases are recorded at the Tomnatec station on the Dragoiasa River.

From the analysis of the data obtained, it can be observed that the total time of the floods is higher on the rivers along the northern frame of the Caliman Mountains, due to the slope accentuated in this part (Table 13). Long floods reach a maximum at Răstolița station, where 95% of the normal floods recorded had a total duration of more than 96 hours. At the Tomnatec station on the Dragoiasa River there were floods with a total duration of less than 24 hours, the highest share of 16.13%.

The smaller the watercourses and the smaller surface area, the shorter the total time, in the basins of the Dragoiasa and Sărișor rivers, the most lightning flash floods were recorded, with values of 16.13% and respectively 10.26%. The lowest frequencies of floods with a total time of more than 96 hours are recorded on the Sarișor River (30.77%) and on the Neagra River

(33.33%). The growth time of a flood shows its extreme danger. The lower this value, the more dangerous the flood.

The negative effects of floods are called floods, appearing when the flows and levels of the rivers exceed the storage capacity of the riverbed. Of the natural risk phenomena, the floods, respectively their effect - floods are among the most dangerous phenomena.

Table 14. Total time (in hours) of flood production

River	Station	0-24 hours		25-48 hours		49-72 hours		73-96 hours		>96 hours		Total	
		No. of cases	%	No. of cases	%	No. of cases	%	No. of cases	%	No. of cases	%	No. of cases	%
Dorna	Poiana	2	3.28	8	13.11	14	22.95	6	9.84	31	50.82	61	100.00
Dornisoara	Poiana	2	5.41	5	13.51	3	8.11	11	29.73	16	43.24	37	100.00
Neagra	Gura	1	2.13	5	10.64	13	27.66	9	19.15	19	40.43	47	100.00
Haita	Gura Haitii	0	0	0	0	3	10.71	0	0	25	89.29	28	100.00
Neagra	Dragoiasa	1	3.70	6	22.22	8	29.63	3	11.11	9	33.33	27	100.00
Sarisor	Panaci	4	10.26	4	10.26	8	20.51	11	28.21	12	30.77	39	100.00
Toplita	Toplita	1	4.55	0	0.00	3	13.64	2	9.09	16	72.73	22	100.00
Dragoiasa	Tomnatec	10	16.13	12	19.35	8	12.90	5	8.06	27	43.55	62	100.00
Rastolita	Rastolita	0	0	0	0	1	5.00	0	0	19	95.00	20	100.00
Bistra	Bistra	0	0	1	10.00	1	10.00	1	10.00	7	70.00	10	100.00

Given that the study area is located in a mountainous area, where the level of housing is low, the effects of the floods on the rivers of the Caliman Mountains are environmental. Due to inudation, the watercourses undergo certain changes due to the geomorphological erosion process.

2.3.2 Periods of low flow (low waters)

Minimum drainage is an important phase of the water regime that must be taken into account when using river water in unmanaged conditions. The drastic decrease of the flows in the small water period has negative consequences on the water supply of the population, industry and irrigation systems, hydropower production, etc.

The periods of low flow are represented annually by the small water phases of winter or autumn and highlighted only in the years characterized by minimum flow, often following periods of floods.

Table 15. The total number of days with low waters for certain time intervals (in days) recorded between 1982-2010 at the stations in the Caliman Mountains

No. Crt.	**River**	**Station**	**< 10**	**10,-20**	**20-30**	**30-40**	**40-50**	**50-60**	**60-70**	**70-80**	**80-90**	**90-100**	**>100**	**Total**
1	**Bistra**	**Bistra**	152	41	11	5	4	5	2	2	0	0	0	222
2	**Bistrita Ard.**	**Mita**	109	29	10	3	5	4	1	4	0	0	1	166
3	**Haita**	**Gura Haitii**	26	12	5	3	1	4	1	1	3	0	3	59
4	**Bistricioara**	**Bilbor**	97	12	5	9	2	5	2	2	2	0	2	138

As can be seen in the tables above, the total number of days with small waters was recorded at Bistra station in the southern part of the Căliman massif (222), followed by the Mița station (166), located on the west side of Călimanului. At the Gura Haitii station, located on the Haita River in the northern part of the Caliman Mountains, there are the fewest days (59) with small waters during the common period analyzed 1982-2020.

Table 16. The percentage of the total number of days with small water (%) for certain time intervals (in days) recorded at the stations in the Caliman Mountains

No. crt.	**River**	**Station**	**< 10**	**10,-20**	**20-30**	**30-40**	**40-50**	**50-60**	**60-70**	**70-80**	**80-90**	**90-100**	**>100**	**Total**
1	Bistra	Bistra	68.47	18.47	4.95	2.25	1.80	2.25	0.90	0.90	0.00	0.00	0.00	100
2	Bistrita Ard.	Mita	65.66	17.47	6.02	1.81	3.01	2.41	0.60	2.41	0.00	0.00	0.60	100
3	Haita	Gura Haitii	44.07	20.34	8.47	5.08	1.69	6.78	1.69	1.69	5.08	0.00	5.08	100
4	Bistricioara	Bilbor	70.29	8.70	3.62	6.52	1.45	3.62	1.45	1.45	1.45	0.00	1.45	100

The duration of periods with small waters on the rivers of the Caliman Mountains varies from case to case. From Table 16 it can be observed that the most common ones are those with short duration (under 10 days), with values between 70.29% at Bilbor station and 44.07% at Gura Haitii station. The high value recorded at the Bilbor station is due to the fact that, at this station, the flow variations were very fast, the flow varying much around the threshold of 80%, with the largest number of days with small water being recorded here. The duration of 10-20 days is followed by weight, but at a great distance (between 8.7% at Bilbor station and 20.34% at Gura Haitii station).

2.4. Tipurile de regim hidric

A sketch on the identification of the types of water regime of the rivers in Romania was published in the manual of Physical Geography developed by V. Mîăilescu (1936). Systematic analyzes of this kind have been carried out since the 6th century of the last century (E. Rosescu, 1957, I.Ujvari, 1957, 1959, D.Lăzărescu, I.Panait, 1958).

The type of distribution of the leak was established after the succession of seasons in calendar order, the majority being the type P.V.T.I., the only exception being the Drăgoiasa station, where the percentage values during the summer slightly exceed those during the spring (Table 17). Using the criterion of the succession of the seasons in decreasing order of the contribution to the annual flow, the mentioned criterion was found that on most of the dominant rivers is type V.T.I.

This type is specific for rivers that run north, east and south, being strongly influenced by the eastern climatic regime, with cold winters and rainier autumns.

Type P.V.I.T. it is specific to the rivers in the western part, where the higher rainfall during the winter determines higher values of the flow in this season, higher than in the autumn.

Table 17. Types of seasonal water flow repartition in Căliman Mountains

River	**Hydrometric station**	**Water flow type**
Dorna	Poiana Stampei	PVTI
Dornisoara	Dornisoara	PVTI
Neagra	Gura Negrii	PVTI
Haita	Gura Haitii	PVTI
Sărisor	Panaci	PVTI
Tomnatic	Drăgoiasa	VPTI
Bistricioara	Bilbor	PVTI
Toplita	Toplita	PVTI
Răstolita	Răstolita	PVTI
Bistra	Bistra	PVTI
Budac	Jelna	PVIT
Bistrita	Mita	PVIT
Bistrita	Bistrita Bârgăului	PVIT
Straja	Mureseni Bârgăului	PVIT

CONCLUSIONS

The study was developed based on data provided by 14 hydrometric stations belonging to the three hydrographic basins: Siret, Mureș and Someș. The network of hydrometric stations is supplemented by the weather stations: Rețitiș, Toplița, Bistrița and Poiana Stampei.

The Caliman Mountains occupy the northwestern part of the central group of the Eastern Carpathians, representing the largest volcanic massif in our country, being severely detached from the neighboring regions by obvious depressive areas in the west Colibița, in the north the Dornelor Depression, in the Black Dragoon, in the east Drăgoiasa, Glodu, Bilbor, Secu, and in the south the defile of Mureș that separates them from the Gurghiului Mountains. They have a maximum altitude of 2100 m at the peak of Pietrosu Călimanului, their shape resembling a rectangle with a length of 60 km on the west-east direction and a width of 30 km from north to south, with an area of about 2000 km² including areas on the territories for Suceava, Harghita, Mureș and Bistrița-Năsăud counties.

In the analysis of the hydrometric network, several criteria were considered, the first being the distribution of hydrometric stations on hydrographic basins, after which the distribution of stations by altitude intervals and then the operating period, the program of measurements and observations resulting from the representativeness of the stations and the possibilities of hydrological synthesis.

The rivers in the Caliman Mountains form the hydrographic basins of Mures, Siret and Someș. The hydrographic network, a component of the physical-geographical environment, is influenced by a number of factors such as: geology of the substrate that crosses it, the energy of the relief, the influence of the edaphic factor, the vegetal carpet, factors of climatic nature (precipitation, temperature, evapotranspiration) and anthropogenic factors of human interaction with the natural environment.

The evolution of the amount of precipitation on a monthly, anotimpual and multiannual level can be characterized by a systematic correlation with geomorphological elements.

The general tendency of the maximum precipitations dropped at the level of the Caliman Mountains is one of increase which implies, in direct correlation, an increase of the amplitude of the floods with pluvial or mixed genesis in the higher area of the studied area.

The altitude distribution of the corresponding values of the balance elements highlights the law of vertical zoning imposed by the altitude of the relief, which represents a synthetic parameter of the conditions of formation and spatial distribution of the components of the water balance.

The maps of the balance sheet items based on the mentioned correlations also highlight the law of vertical zoning, as well as the contrasts that appear between the west and the east of the studied region.

From the analysis of the water balance on hydrographic basins it is noted that over two thirds of the water resources are realized in the territories located in the western and central part of the Caliman Mountains, where the water circuit is more intense, which favored the accomplishment of accumulations that replace the water deficit from the Transylvania Depression.

The feeding and the regime of the hydrographic network belonging to the Căliman Mountains reflect a set of conditions from which the climatic ones and those related to the place-morphology of the places have relevance.

High water periods represent slow increases in river flows and maintain them at high rates for a period that may vary between a few days and in exceptional cases a few weeks or months. This phenomenon is due to the slow melting of the snow layer existing in the Caliman Mountains from the late spring period.

The periods of low flow are represented annually by the small water phases of winter or autumn and highlighted only in the years characterized by minimum flow, often following periods of floods.

Analyzing the daily flow regime, of the rivers in the Caliman Mountains, we can say that it is characterized by periods of high flow, materialized in the form of periods of high water and floods, frequent in spring, and periods of low flow that characterize the rivers in this area. the winter season mainly in the December-January monthly period as a result of the negative thermal regime that determines the storage of a large quantity of water in solid form and the blocking of the watercourses.

The anthropic impact on the average annual drainage of the rivers in the Caliman Mountains is a small one, their drainage regime is not a strong anthropic one, at the level of the study period, the human influence being highlighted by some changes undergone by the hydrotechnical threats.

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