THE PECULIARITIES OF THE HIGH FLOODS IN THE UPPER CRASNA BASIN

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Abstract: The present paper analyses the characteristics of the high floods on the rivers in the Upper Crasna Basin, mainly developed in the space between Meseş and Plopiş Mountains, where this extreme hydrological hazard has a quite high frequency, being an important risk for the population and the settlements in the mentioned area.
In order to assess the risk induced by high floods we considered useful highlighting the factors that determine or influence the triggering and the development of high floods.
The second aspect of this paper was the analysis of temporal, quantitative and dynamic parameters of high floods, which reflect the impact that this extreme hydrological hazard may generate. The assessment of the average, maximum and minimum values of these parameters was made in order to identify the most appropriate measures for the prevention and mitigation of the effects that high floods may induce (especially floods).

Key words: high floods, triggering and influencing factors, temporal, quantitative and dynamic parameters

1. INTRODUCTION

The studied region corresponds to the upper Crasna Basin, situated upstream of the confluence on the right with Zalau stream. Crasna, a tributary on the left of Somes River, collects a series of dendritically organized tributaries and shows a quite pronounced leftwards asymmetry in the studied area, while the asymmetry is rightwards downstream of the confluence with Zalau.

The leftwards asymmetry is more obvious in Simleu Depression where it receives Somoşia, Zănicel and Şoldubița. From the right, until the confluence with Zalau, Boului and Pria streams come into prominence, streams come from the saddle between Meseş and Plopiş Mountains. From the left it receives Ponița, Seredeanca, Catrici and Colițca come from the Meseş Mountains. The most important tributary come from the Meseş Mountains is Zalău, which it receives downstream of the locality of Sărmăşag.

It has an asymmetric basin developed mainly on the left side, collecting some tributaries come from the Meseş Mountains (Mița) and Şimleu Hummock (Siciu and Lăscut).

High floods were included in the category of extreme hydrologic processes and phenomena (Sorocovschi), differentiating from drought by the developing manner and means of prevention and mitigation. On must take into account the characteristics of the extreme hydrologic processes and phenomena when designing, building and using the hydraulic structures because their destructive effects hold an important share among natural hazards.

2. DATA BASE AND METHODS

In order to carry out the present study we used the date from three hydrometric stations on Crasna River (Crasna and Şimleu Silvaniei) and Zalău stream (Borla), from eight rainfall stations and one meteorological station (Zalău). The period considered for the study of high floods was 1974-2010, noting that there were several interruptions (Table 1). For the assessment of the triggering factors of high floods we considered the period between 1990-2010.

Table 1. Data referring to the considered hydrometric stations

Name of the hydrometric station	River	Area (km^2)	Altitude (m)	Observation period	No of analyzed high floods
Crasna	Crasna	196	255	1974 - 1987; 1989 - 2010	72
Şimleu Silvaniei	Crasna	403	205	1974; 1976 - 1981; 1984; 1993 - 2010	52
Borla	Zalău	170	193	1974; 1979 - 2010	64

For the survey of high floods we selected the first two high floods in each year, with direct observation data. This led to an unequal number of analyzed high floods for each station, fact that does not ensure the best reliability of the results.

Among the frequently used methods in data processing we can mention the statistic ones. As specific methods we used Cavis in order to determine the parameters of the high flood waves and special working techniques (Angot index and WASP) for the determination of exceeding rainfall periods.

3. RESULTS AND DISCUSSIONS

In order to identify the main parameters and characteristics of the high floods of the streams in the Upper Crasna basin we have analyzed in the first place the triggering and influencing factors. Later we have shown the peculiarities of the temporal and qualitative high flood parameters and in the end their typology.

3.1. The triggering and influencing factors of high floods

There are two categories of factors: triggering and influencing. In the first category we included the meteorological factors: liquid precipitation (quantity, intensity, duration) and/or solid (the density and thickness of the snow layer the water reserve depends on), air temperature or their combination. The potential of high floods is influenced by morphological, morphometric and other factors that characterize the degree of humidity of the basin at the moment when the triggering meteorological phenomenon takes place.

The atmospheric precipitation and the characteristics of the snow layer act separately (leading to pluvial high floods or high floods caused by snow melt) or may act together causing mixed high floods (pluvio-nival or nivo-pluvial).

Precipitations**,** no matter their way of manifestation (liquid or solid) directly influence the starting of the high flood waves. The liquid ones have an immediate effect, while the influence of the solid ones is felt after a certain time, in the moment when the air temperature becomes positive leading to the melting of the accumulated snow and ice.

In order to highlight the degree of soil moisture before the triggering meteorological phenomenon took place, we analyzed the annual and seasonal precipitation by means of the weighted anomaly standardized precipitation method. The data processing led to the conclusion that the average frequency at the level of the region of very rainy years is low (3.17 %), while the frequency of the years with risk by exceeding rainfall is of 18.5 % (fig.1).

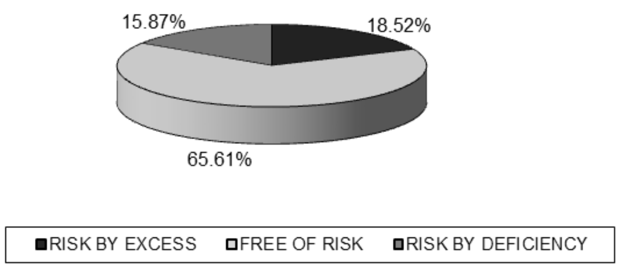
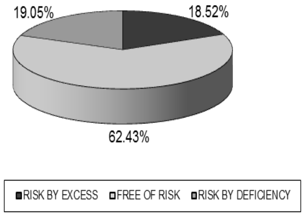


Figure 1. The average frequency of the years with rainfall risk or free of risk in the Upper Crasna Basin

This group includes the extremely rainy, very rainy and moderate rainy years (Table 2).The very rainy cold seasons had a low frequency (0 %- 4.76 %), as compared to the moderate rainy ones (9.52 % - 23.81%) or the little rainy ones (4.76 % - 33.33 %). At Sărmăşag, Meseşeni and Şimleu Silvaniei stations the frequency of the moderate rainy cold seasons (9.52 % - 23.81 %) exceeds that of little rainy cases. At the rest of the stations the situation is the other way round. The very rainy hot seasons had a low frequency (4.76 %) as compared to the moderate rainy ones (9.52 % - 23.81%) or the little rainy ones (4.76% - 23.81%). The risk given by the exceeding rainfall in the hot season is less frequent than the risk given by the absence of rainfall (fig. 2).

Table 2. The years with rainfall risk by excess at the rainfall stations in the Upper Crasna Basin

Rainfall station	Rainfall mark					
	Extremely rainy		Very rainy		Moderate rainy	
	Years	%	Years	%	Years	%
Borla	-			-	1998, 2001, 2010	14.29
Şimleu Silvaniei	-		2010	4.76	1998. 2001, 2005	14.29
Crasna	-		2010	4.76	1997, 2001,2005	9.52
Zalău	-			-	1998, 2001, 2005, 2010	19.05
Varşolţ	-		2010	4.76	1997, 1998, 2001	14.29
Meseşeni	-			-	1997, 1998, 1999, 2001	19.05
Bănişor		-		-	1997, 1998, 1999, 2001, 2010	23.81
Sărmăsşag		-		-	1996, 1998, 2008, 2010	19.05
Stârciu		-		-	1997, 1998, 2001, 2010	19.05



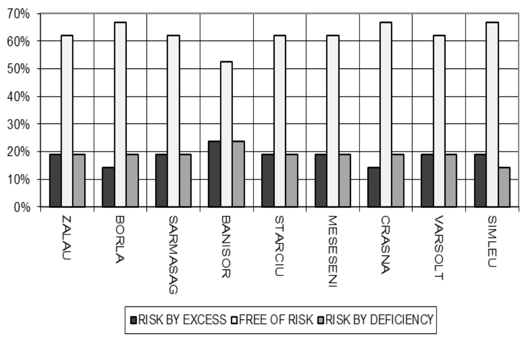


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Figure 2. The average frequency of hot seasons with rainfall risk or free of risk in Upper Crasna Basin (a) and at the meteorological and rainfall stations (b)

In order to highlight the excess or the deficit of rainfall at monthly level we used the Angot monthly rainfall index. The rainiest months in the study period (1990-2010), were the summer ones, (Table 3) when besides the frontal rainfalls, the convective ones play an important part.

Table 3. The monthly values of the Angot rainfall index

Crt no.	Rainfall station	Year and month	The value of the rainfall index
1	Borla	September 1996,August 2006	3.27; 2.84
2	Şimleu Silvaniei	June 2009 , July 2000	3.21; 3.00
3.	Crasna	July 2000, August 2006	3.04; 2.92
4.	Zalău:	August 2006, May 1991	3.39; 3.08
5.	Vârşolţ	June 1998, July 2000	3.78; 3.20
6.	Meseşeni:	June 1998, August 2006	3.73; 3.00
7.	Bănişor:	July 2000, October 1992	3.52; 3.21
8.	Sărmăşag	July 2008, August 2006	3.28; 3.21
10	Stârciu	August 2006, July 2004	3.12; 3.00

There were cases when the rainiest months were signaled at the end of the spring and at the beginning of the autumn (Table 3)

The summer high floods were caused by the maximum precipitation in 24 hours, which in the summer months frequently exceeded 40 - 50 mm, even reaching values of over 90 mm (Table 4).

Tabel 4. The maximum precipitation in 24 hours fallen at the meteorological and rainfall stations in the Upper Crasna Basin (1990-2010)

Rainfall station	Month												Annual maximum
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	
Borla	15.5	27.8	22.5	25.9	41	60.6	93.2	58	34.5	44.2	32	27.5	93.2 13.07.92
Şimleu Silvaniei	19.3	18	27.7	28	29.3	80	58.7	36	44.2	42.6	28	34	80.0 06.1996
Vârşolț	16	25	25	28	63.2	40	63.2	41.7	35.5	49.3	34.5	27.3	63.2 23.05.99
Crasna	16.8	29.3	22.3	25.1	32.9	48.2	75.5	42.7	45.8	64.2	31.8	34.9	75.5 24.07.10
Stârciu	14.9	27.8	26.5	32	42	65.6	51	52	60.2	51.9	30	33.6	60.6 23.06.09
Meseşeni	14.8	26	22	32.2	33.8	53	53.7	51.7	34.3	48.2	27.9	31.4	53.7 25.07.10
Bănişor	14.1	20.4	39.4	30	39.4	71.5	56.3	50.6	41.5	52.8	27.7	36.5	71.5 9.06.99
Sărmăşag	17.7	32.6	17.1	26.1	27.2	53	49	60.6	49	35.5	29.6	22.9	60.6 24.08.05
Zalău	17.2	20.5	22.2	36.3	56	45	48	55.6	46.2	57.4	35.9	25.3	57.4 19.10.96

The maximum precipitation fallen in 24 hours equaling or over 20 mm have a quite long duration between 45 (Sărmăşag) and 82 days (Şimleu Silvaniei) (Table 5).

Table 5. The number of days corresponding to different thresholds of maximum precipitation fallen in 24 hours (1990-2010)

No of days / Precipitation	Borla	Şimleu Silvaniei	Vârşolt	Crasna	Stârciu	Meseşeni	Bănişor	Sărmăşag	Zalău
≥20 mm	77	82	70	79	67	72	86	45	73
10-19.9 mm	100	85	78	91	85	85	84	58	100
<0-9.9 mm	75	85	104	82	100	65	52	55	79

At the level of the whole basin, the number of values over 20 mm hold 36.23 % of the total, while those between 10 -19.9 mm cover 32.97 %. At the most rainfall stations the highest frequency of the maximum precipitation fallen in 24 hours with values over 20 mm (the one which causes high floods) is assigned to the hot season, and especially to the summer months (June and July) and the beginning of autumn (August and September) (Table 6).

Table 6. The monthly and seasonal frequency of the maximum rainfall in 24 hours exceeding 20 mm (1990 – 2010)

Rainfall station	H (m)	Maximum monthly frequency		Minimum monthly frequency		Seasonal frequency (%)	
		%	Month	%	Month	V - X	XI - IV
Borla	193	19.48	VII	0	I	83.12	16.88
Şimleu Silv.	205	15.85	VII, IX	0	I, II	81.71	18.29
Vârşolţ	244	20	VII	0	I	85.71	14.29
Crasna	255	18.99	VII	0	I	79.75	20.25
Stârciu	365	16.42	VI, VII, IX	0	I	80.6	19.4
Meseşeni	255	18.06	VII	0	I	81.94	18.06
Bănisor	299	17.44	VI	1.16	II	76.74	23.26
Sarmaşag	167	17.78	VI, VII,VIII	0	I, III	88.89	11.11
Zalău	257	21.92	VI	0	I	82.19	17.81

The snow layer contributes to the triggering of high floods by means of thickness, persistence in time and the melting duration. The duration of the snow layer mainly depends on the air temperature, which is in close connection with the altitude. In the mountains, the snow layer lasts for more than 80 days, while in the lower hills it lasts less than 60 days.The volume of water stored in the snow layer depends in the first place on its thickness. This stored water will contribute to the apparition of spring high waters and high floods once the state of aggregation changes. This parameter is closely related to the degree of afforestation, altitude, slope exposure, the angle of inclination of slopes, the direction and intensity of local winds, air temperature, etc.

By the slow melting of the snow layer, once the temperature becomes positive, an additional quantity of water is produced (overlapped or not over a series of liquid precipitation), fact leading to the increasement of the flowing coefficients. Under these circumstances, mixed high floods on river may take place. The average thickness of the snow layer stays between 2 and 7 cm. the highest values are recorded in January and February (4 cm multiannual average), while the lowest values are recorded in April and November when the snow layer appears sporadically (Table 7).

Table 7 The multiannual average of the snow layer thickness (cm) at the rainfall stations in Upper Crasna Basin between 1993 – 2010

Rainfall station	I	II	III	IV	XI	XII	Multiannual average
Borla	4	6	1	0	0	2	**2**
Simleu Silvaniei	4	4	1	0	1	2	**2**
Varsolt	3	7	1	0	0	1	**2**
Crasna	3	4	1	0	0	2	**2**
Meseseni de Jos	3	4	1	0	0	2	**2**
Banisor	4	5	2	0	1	2	**2**
Starciu	4	5	1	0	1	2	**2**
Sarmasag	4	5	2	1	1	2	**2**
Grosimea medie	**4**	**4**	**1**	**0**	**0**	**2**	**2**
Grosimea maxima	**4.1**	**7.1**	**2.1**	**0.7**	**0.7**	**2.3**	**2.4**
Grosimea minima	**2.7**	**3.5**	**0.8**	**0.1**	**0.4**	**1.5**	**1.7**

3.2. High floods parameters

High floods can be characterized by a series of temporal and qualitative parameters which give the opportunity of preventing and mitigating the effects induced by this extreme hydrological event.

3.2.1. Temporal parameters

Identifying the temporal parameters (frequency and duration) is extremely important for the assessment of the degree of risk the areas vulnerable to the negative effects induced by the high floods are exposed to, and also for taking the right action for their prevention and mitigation.

The frequency of high floods. When calculating the frequency we took into account the difference between normal and important high floods. The normal high floods are those included in the spreadsheets with the greatest two high floods in every year; the important ones were obtained by removing those whose peak discharge was not higher or equal to the maximum average annual discharge (Anițan, 1974; Centea, 1974, quoted by Arghiuş, 2008) .Important high floods hold different shares out of the whole normal high floods. The greatest number of important high floods was recorded at Crasna and Borla hydrometric stations (Table 8)

At all hydrometric stations taken into study the normal high floods have maximum frequencies at the end of the spring, namely in May and during summer in June and July (Table 9). The explanation stands in the fact that in the above-mentioned periods the highest quantities of frontal and especially of thermic convection origin are recorded.

Table 8. The normal and important high floods recorded at the hydrometric stations in the Upper Crasna Basin (1974 – 2010).

Hydrometric station	River	Q av annual maximum (m^3/s)	No. of normal high floods	No of important high floods	
				Absolute	% of the normal high floods
Crasna	Crasna	49.78	72	34	47.2
Simleu Silvaniei	Crasna	48.99	52	4	7.7
Borla	Zalău	25.66	64	33	51.2

Table 9. The monthly frequency of normal high floods recorded in the Upper Crasna Basin (1974 – 2010).

Hydrometric station	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Crasna	5.6	6.9	8.3	13.9	11.1	25.0	11.1	6.9	2.8	4.2	1.4	2.8
Simleu Silv.	5.8	13.5	13.5	13.5	7.7	19.2	11.5	3.8	3.8	3.8	1.9	1.9
Borla	6.2	9.4	12.5	10.9	12.5	15.6	10.9	9.4	6.2	4.7	0.0	1.6

Calculating the seasonal frequency of normal high floods one can notice the fact that the highest share is held by summer, followed by spring and winter. During autumn, because of the small quantities of rainfall and of the exhaustion of underground water reserves, the frequency of high floods is lowest (Table 10).

Table 10. The seasonal frequency (%) of normal high floods in the Upper Crasna Basin (1974 -2010)

River	Hydrometric station	F (km²)	H (m)	Winter	Spring	Summer	Autumn
Crasna	Crasna	196	255	15.3	33.3	43.1	8.3
Crasna	Şimleu Silvaniei	403	205	21.1	34.6	34.6	9.6
Zalau	Borla	170	193	17.2	35.9	35.9	10.9

As the case of normal high floods, the important ones take place more frequently during summer, holding half of the total (Table 11). The share held by the important high floods during spring (35.21%) is close to that of the normal high floods in this season.

Table 11. The seasonal frequency (% of the total) of important high floods

Hydrometric station	Winter	Spring	Summer	Autumn
Borla	9.0	36.4	48.5	6.1
Crasna	5.9	32.3	55.9	5.9
Simleu Silvaniei	0.0	50.0	50.0	0.0

In winter the share held by the important high floods is much lower than that of the normal ones. The highest frequency was recorded at Borla hydrometric station (9.1 %). As for normal high floods, the lowest frequency was recorded during autumn, when the share held by the important high floods was between 0 and 6.1%.

The frequency of high floods according to genetic types. Considering the period May – November representative for the occurrence of pluvial high floods and December – April for those of mixed origin, one can notice a quite balanced repartition of the high floods of pluvial and mixed origin, high floods recorded at the hydrometric stations in the studied basin (Table 12).

Table 12. The frequency of high floods according to genetic types (%)

River	**Hydrometric station**	**Area (km^2)**	**Altitude (m)**	**Pluvial high floods (V- XI)**	**Mixed high floods (XII - IV)**
Crasna	Crasna	196	255	62.5	37.5
Crasna	Simleu Silvaniei	403	205	51.9	48.1
Zalau	Borla	170	193	59.4	40.6

The high percentage held by the mixed high floods can be explained by means of the frequent intercalation of periods with positive air temperature during winter as a result of the penetration of warm air masses from West and North-West.

The duration of high floods **(**total, up going and down going) is an important temporal parameter for the assessment of the risk induced by the apparition and development of this extreme hydrological phenomenon.

According to the values obtained for the total duration the simple and composed high floods were framed into five categories with values between 0 - 24 hours and over 96 hours. The highest frequency (between 71% and 76 %) corresponds to the high floods with a total duration of over 96 hours, while the lowest corresponds to those in the first category (Table 13). Out of the analysis of the obtained data results the fact that during the analyzed period flash floods appeared very rarely, namely a single case at Crasna hydrometric station, with duration of under 24 hours (the 3rd of November 7am. – the 4th of November 7 am. 1976). On the other hand, the high floods with extremely long duration hold an important share and they may be classified as high waters. In this respect, we can mention the high flood recorded at Şimleu Silvaniei hydrometric station, between the 4th of April and the 19th of May 1993, which had a total duration of 958 hours.

In order to analyze the up going duration we selected five value classes (table 14). The short up going time (0 - 6 hours, respectively 7 - 12 hours) allows detecting the high floods with a rapid evolution and those of the *flash-flood type*, which are the most dangerous as the short time does not allow taking quick action for preventing the dangers they may induce.

Table 13. The total duration of high floods in the Upper Crasna Basin (number of cases and %)

Hydrometric station	High floods with a total duration of (hours)									
	0-24		25-48		49-72		73-96		>96	
	No. of cases	%	No. of cases	%	No. of cases	%	No. of cases	%	No. of cases	%
Crasna	1	1.4	4	5.6	5	6.9	7	9.7	55	76.4
Şimleu Silvaniei	0	0	1	1.9	4	7.7	1	1.9	46	88.5
Borla	0	0	2	3.1	8	12.5	8	12.5	46	71.9

Tabel 14. The up going duration of high floods in Upper Crasna (in number of cases and %)

Hydrometric station	High floods with an up going duration of (hours)									
	0-6		7-12		13-24		25-48		>48	
	No. of cases	%	No. of cases	%	No. of cases	%	No. of cases	%	No. of cases	%
Crasna	2	2.8	6	8.3	13	18.1	22	30.6	29	40.3
Simleu Silvaniei	0	0.0	1	1.9	2	3.8	15	28.8	34	65.4
Borla	2	3.1	3	4.7	13	20.3	16	25.0	30	46.9

Almost half of the recorded high floods (49%) have an up going time of over 48 hours. It is followed by the group with values between 25 - 48 hours (28.2%), while the lowest frequency is held by the high floods with an up going time of under 6 hours (only 2.1%).

Out of the analysis of the high floods duration one can notice a good correlation with the area of the controlled catchments. At the stations with small catchments the total and up going duration is also short. The values of the duration of high floods grow together with the area of the catchments. At Crasna and Borla hydrometric stations, with similar areas the total and up going durations have close values. In the case of Şimleu Silvaniei station, with a double area as compared to the other two one can notice a total and up growing duration approximately twice as long. The morphometric characteristics of the catchment (area, shape, gradient and altitude, the degree of horizontal and vertical fragmentation of the relief of the catchment) influence the size and especially the speed of the high floods.

The geomorphometry of the slopes, the geometric characteristics of the river major and minor channel (the shape of the cross-section of the channel, the horizontal morphology of the channel, the length of the channel network) and the length of rivers on size orders, mainly influence the duration of the high flow.

The volume of water that flows for the same quantity and spatial-temporal distribution of the rainfall that triggers the high flood is influenced by other factors: the degree of soil moisture before the occurrence of the triggering meteorological phenomenon, which influences the possibilities of water infiltration, much diminished in the case the degree of soil moisture is high; the level of the sub surface water and the frozen soil also influence the capacity of water infiltration into the soil; the way the soil was treated for agricultural purposes and the changes in land-use (the degree of urbanization), massive afforestation or deforestation in the catchment area influence the share held by the basic components of flow: surface and sub-surface.

3.2.2 Quantitative parameters

This category includes those parameters (discharges, levels, volumes) which influence the action capacity of high floods (magnitude, energetic impact).

Knowing the discharge reached the moment when the up going period is over (maximum discharge) is important for the assessment of the impact this hydrological hazard can produce. The analysis of the determined maximum discharges (average, specific) highlights the role of certain factors, of which the most important are: the area of the catchment, the peculiarities of the surface, the degree of vegetation coverage and the peculiarities of the vegetal associations, the slope of the terrain and of the rivers, the presence of water reservoirs and swamps.

The maximum discharges of the high floods recorded at the hydrometric stations in the studied basin range between 143 m^3/s and 224 m^3/s (Table 15). In order to assess the impact a high flood may produce we calculated the Myer-Coutagne-Pardé index (or the index of the strength of the high flood, expressed in $m^3/s/km^2$) (Table 15).

Table 15. The values of the maximum discharges (absolute, average, specific) and of the Myer-Coutagne-Pardé index at the hydrometric stations in the Upper Crasna Basin (1974-2010)

Hydrometric station	F (km^2)	$Q_{max.abs.}$ (m^3/s)	Date of occurence	$Q_{max. med}$ (m^3/s)	$q_{max. med.}$ ($l/s.km^2$)	$A_{max.}$ ($m^3/s/km^2$)
Crasna	196	224	25.07.2010	70.32	363.08	15.96
Şimleu Silvaniei	403	203	23.07.1974	23.39	58.05	10.11
Borla	170	143	31.08.1989	34.45	202.70	10.97

The value of the maximum specific discharge goes down once the surface of the catchment corresponding to the hydrometric station goes up. The values of the

A parameter fits in the normal values for the region the catchment is situated in (under 10 $m^3/s/km^2$) (Table 16)

Tabel 16. The average values of the Myer-Coutagne-Pardé index for the Upper Crasna Basin (1974-2010)

Crt. no	Hydrometric station	River	F (km^2)	A med ($m3/s/km^2$)
1.	Crasna	Crasna	196	4.87
2.	Simleu Silvaniei	Crasna	403	1.16
3.	Borla	Zalau	170	2.64

This parameter had annual values higher than 10 $m^3/s/km^2$ in 14 cases, out of which 11 only for Crasna hydrometric station and one for each of the stations Şimleu Silvaniei and Borla. The absolute maximum value of this parameter was of 15.96 $m^3/s/km^2$ recorded at Crasna hydrometric station on the 25th of July 2010 for a maximum discharge of the high flood of 224 m^3/s (with a corresponding level of de 508 cm).

Maximum levels. The average values of the maximum levels ranged between 325.73 cm at Crasna hydrometric station and 375.98 cm at Şimleul Silvaniei hydrometric station (Table 17).

Tabel 17 The average, maximum and minimum levels of high floods in Upper Crasna Basin

Hydrometric stations	F (km^2)	Average level (cm)	Maximum level (cm)		Minimum level (cm)	
			Level	Period	Level	Period
Crasna	196	325,73	580	22.06 – 2.07 2009	102	3 – 5.10 1998
Şimleu Silvaniei	403	375,98	686	27.07 – 3.07 2009	212	19 – 31.07 1974
Borla	170	336,67	548	3 – 6.07 2009	115	21 - 25.07 1974

Analyzing the frequency with which the levels recorded at the hydrometric stations in the Upper Crasna Basin overcame the attention, inundation and danger levels we noticed that over half of the high floods recorded at Borla hydrometric station overcame the danger level (Table 18). Instead at Şimleu Silvaniei hydrometric station the frequency of the levels that overcame these levels is much lower (13.6 %) because of the diminishing role of the Vârşolț reservoir.

Table 18. Number of cases and the frequency (%) of high floods which overcame the attention, inundation and danger levels (1974 – 2010).

Hydrometric station	> AL		> IL		> DL	
	Nr.	%	Nr.	%	Nr.	%
Crasna	52	72,2	39	54,2	26	36,1
Simleu Silvaniei	42	80,8	21	40,4	7	13,5
Borla	46	71,9	41	64,1	35	54,7

The volume of high floods. The volume of high floods, the same as the discharge, goes up together with the size of the catchment. So, the average volume for Crasna river, grew from 4.25 mil.m^3 at Crasna hydrometric station to 7.52 mil.m^3 at Şimleu Silvaniei station (Table 19).

Tabel 19. The average, maximum and minimum volumes of high floods at the hydrometric stations in the Upper Crasna

Hydrometric station	F (km²)	Average volume (mil. m^3)	Maximum volume (mil. m^3)		Minimum volume (mil. m^3)	
			Volume	Period	Volume	Period
Crasna	196	4,255	25,617	23.07 – 2.08 2010	0,370	2 – 5.07 1983
Şimleu Silvaniei	403	7,529	35,975	1 - 21.06 1974	0,016	10 – 16.06 1994
Borla	170	2.457	14,095	6 – 21.06 1974	0,151	2 – 6.08 1984

Depth of runoff. This parameter has higher values in the mountains where the slopes and the degree of forestation are higher**.** The average values of high floods' depth of runoff range between 14.8 and 21.2 mm, while the maximum values reach 130 mm (Table 20).

Table 20. The average, maximum and minimum values of the depth of runoff during the high floods in the Upper Crasna Basin (1974-2010)

Hydrometric station	F (km²)	Depth of runoff (mm)				
		Average	Maximum / Period		Minimum / Period	
Crasna	196	21,22	130,7	23.07 – 2.08.2010	1,89	2 – 5.07 1983
Şimleu Silvaniei	403	18,68	89,27	1 - 21.06 1974	0,04	10 – 16.06 1994
Borla	170	14,84	89,91	6 – 21.06 1974	0,89	2 – 6.08 1984

Shape coefficient. The average values of the shape coefficients of the analyzed high floods range between 0.16 and 0.40, while the extreme ones are between 0.02 and 0.75 (Table 21).

Table 21. The average, maximum and minimum values of the shape coefficient of high floods in Upper Crasna Basin(1974 – 2010)

River	Hydrometric station	F (km^2)	Shape coefficient		
			Average	Minimum	Maximum
Crasna	Crasna	196	0,16	0,02	0,49
Crasna	Şimleu Silvaniei	403	0,40	0,07	0,75
Zalau	Borla	170	0,19	0,04	0,51

Calculating this parameter allows the separation of high floods in two categories, out of which the composed ones are the most frequent and the most dangerous. One may notice an increasement of the frequency of composed high floods together with the growing of the area of the catchment (Table 22).

Table 22. The frequency of simple and composed high floods in the Upper Crasna basin (%)

River	Hydrometric station	F (km^2)	Simple high floods	Composed high floods
Crasna	Crasna	196	37.5	62.5
Crasna	Simleu Silvaniei	403	19.2	80.8
Zalau	Borla	170	40.6	59.4

CONCLUSIONS

Among the natural hazards in the Upper Crasna Basin, high floods have a high frequency, sometimes having disastrous effects (1970, 1978, etc.).

The triggering and development of high floods is determined and influenced by a series of natural and human factors, out of which we paid special attention to the climatic ones. Knowing the way of manifestation of these factors allows prevention and taking the most appropriate measures of mitigating the effects induced by this extreme hydrological hazard.

Highlighting the values the temporal, quantitative and dynamic parameters of high floods vary between allows a better assessment of the degree of risk the population and the settlements in the studied area are exposed to.

As a theoretical aspect, the high frequency of high floods during winter underlines the type of Western peri-Carphatian regime, proper to the rivers in the Upper Crasna Basin.

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