THE SIGNIFICANT FLASH FLOODS IN VIȘEU RIVER BASIN, ROMANIA. CAUSES AND EFFECTS ON THE FLOODPLAIN

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ABSTRACT. - The significant flash floods in Vișeu River basin. Causes and effects on the floodplain. Vișeu's river basin location and morphometry has offered, over the course of time, favourable conditions to the formation of different types of floods. Their increase over the last time due to climate change and chaotic anthropic activities has led to visible changes of the morphology of the floodplain. The present paper analyses the genetic factors, the significant floods and in particular, the impact of these floods on the floodplain of Vișeu river and its main tributaries, Ruscova, Vaser and Țâșla.

Keywords: Vișeu, flash flood, floodplain, causes, effects.

1. INTRODUCTION, METHODOLOGY AND DATABASE

Located in the central area of the northern group of the Oriental Carpathian mountains, morphologically, Vișeu river basin has seen a strong anthropization since 1765 along with the colonisation of the "țipțer" population around Vișeu area, so far developing along the main valleys, Vișeu, Țâșla, Vase, Ruscova, 2 towns and 8 villages, adding together over 665000 inhabitants.

The high frequency of flash floods which generate a great impact on the local society and economy is caused especially by natural conditions. The morphogeographical characteristics favourable to the western atmospheric circulation which generates high rainfall and the assymetrical shape of the basin provides all the genetic conditions favourable to flash floods which once produced initiates and accelerates the negative geomorphological processes on the local area and the infrastructure.

Anthropic activities also have a great influence on the genesis of the floods occured over the course of time. Among these we mention: mining, forests clearance and wood processing, agriculture and animal breeding. These activities are usually done in a chaotic manner, and even ilegally in the case of forests clearance.

The data used in the analysis of the main flood waves and their corresponding effects have been collected from reports created by the Water Basin Administration Someş-Tisa, including the Water Management System that manages the Vișeu basin, as well as from the local and county authorities present in the basin.

The interval of analyzed data is between 1970 – present. The water data used in the analysis of the flood waves has been collected from the Water

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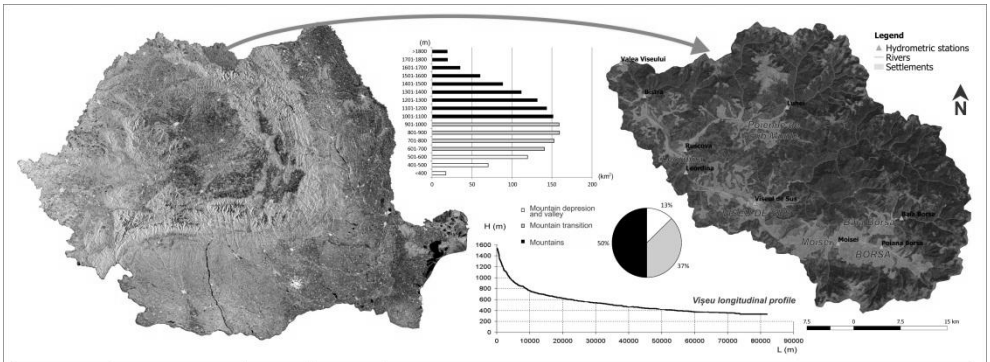
Basin Administration Someş-Tisa and different specialized papers, while the meteorological parameters have been collected from different specialized websites.

For cartographic support there have been used surveying maps and detailed map drawings owned by the Faculty, as well as satellite imagery. In order to emphasize the results there have been used cartographic and graphic procedures as well as photographic documents either personal or collected from the mass-media.



River	Hydrometric Station	F (km2)	H med (m)	Hydrological Parametres			
				Qmed (m3/s)	Q max 1% (m3/s)	Q min 95% (m3/s)	R (kg/s)
Vișeu	Bistra	1557	1020	34.3	1155	5.9	13.35

Fig. 1. ***Vișeu hydrographical basin***

2. HISTORICAL AND SIGNIFICANT FLASH FLOODS

The genesis of flash floods in Vișeu river basin is mainly pluvio-nival (61%). The monthly frequency of floods presents a peak during March for Vișeu's main stream as well as secondary peaks during April and May, meanwhile its right tributaries Țâșla, Vaser and Ruscova present a peak during April, with secondary peaks during March and May.

The lowest frequency level of floods is during January (0%). The seasonal frequency of floods highlights a peak during spring, followed by floods during summer, autumns and winter *(Cocuț, 2008).*

The most significant flash floods in Vișeu river basin recorded between 1970-present, selected both depending on the aspect of the levels or the recorded peak flows and the damage occurred, are those from 1970, 1974, 1995, 1998, 2001 and 2008.

According to the report „Preliminary flood risk assessment" drawn-up by the Water Basin Administration Someș-Tisa, pursuant to Directive 2007/60/EC of the European Parliament and of the Council of 23 October 2007 on the assessment and management of flood risks, the location in time and space of the historical floods is the following (Table 1):

Table 1. ***The historical floods in Vișeu river basin (source: Directive 2007/60/CE)***

No.	Flooded locations	Event date / Event period (days)	Flooded area (km^2) / Flooded river segment (km)	Frequency
1	Ruscova r. - Bardi ds. confl.	1970-05-10 / 2 days	-/ 20.091 km	1%
2	Vișeu r. - Țâsla us. confl.	1970-05-10 / 2 days	10.805 km^2 /-	1%
3	Ruscova r. - Bardi ds. confl. and Repedea tr	2001-03-05 / 3 days	-/ 22.446 km	5%
4	Vișeu r. - ds. confl. Vaser and Vaser tr.	2001-03-05 / 3 days	-/ 46.205 km	3%
5	Țâsla r. - ds. confl. Secul and Secul tr.	2008-07-26 / 3 days	-/ 9.757 km	1%
6	Vaser r. - Novăț ds. confl.	2008-07-26 / 3 days	-/ 11.972 km	1%
7	Ruscova r. - Bardi ds. confl. și Repedea tr.	2008-07-26 / 2 days	-/ 22.446 km	1%
8	Vișeu r. - Țâsla ds. confl.	2008-07-26 / 3 days	10.805 km^2 /-	1%

3. CAUSES AND MAIN CHARACTERISTICS

May 1970. The flash flood of 12-15 May 1970 is the second most important from Vișeu river basin. The pluvio-nival flood has occured due to the previous period, January-May, which was characterized by double amounts of rainfall than the multiannual normal average. During the months of winter the layer of snow in the mountains was very consistent, later on entering a melting process during April. During the month of May, the rainfalls resulted from the rise of the mediterannean warm and humid mass of air have determined the formation of some cumulonimbus clouds as well as a great thermodynamic instability with hail phenomena. These rainfalls have been favoured even by some succesive cold fronts coming from Central Europe. In this way, on Vișeu basin's surface precipitations have fell on a ground already saturated with water, precipitations which have added up quantities of more than 100mm in the mountainous area of the basin. The rainfalls and the melting of the snow have generated peak flows between 34 and 1072 m^3/s, with probabilities of occurrence which reached 1% on Vișeu at Leordina and Bistra, and the flood volumes have had values between 2mil. m^3 and 82 mil. m^3 on Vișeu at Bistra.

July 1974. Another important pluvial flood with major impact on Vișeu river basin was the one between the 21st and the 26th of July, 1974. The rainfalls which generated the flood have had values between 68,8 and 109,2 mm, producing a flood with peak flows comprised between 42 and 651 m^3/s with high probabilities of overflow between 23% on Ruscova at Luhei and 3% on Vișeu at Leordina. The flood volumes were comprised between 3,24 mil.m^3 on Ruscova at Luhei and 53,5 mil.m^3 on Vișeu at Bistra.

December 1995. During December 23-29, 1995 there was a mixed pluvio-nival flood, characterized by significant levels and peak flows, as well as by spatial extent. December 19-21 , 1995 was characterized by low temperatures and small amounts of snow, favored by the leakage of polar air masses coming from W-NW. The depth of the snow layer in Vișeu river basin was measuring 18 cm with an equivalent in water of 36 mm. The 23rd of December brought increases in temperature, therefore producing the melting of the snow on which precipitations fell. These occurred due to the Icelandic depression which descended on the

continent, favoring in this way in central Europe an intense western circulation which brought clouds and precipitations at the beginning in forms of rain and snow and later on, starting with the 26th of December in form of rain with an average of 15-25 l/m2. Diurnal thermal values turned positive, and the layer of snow has been considerably reduced on all over the surface of the basin. The abnormal warm weather for this period has continued until the 29th of December with consistent rainfalls and downpour character. The rainfalls which generated the flood have had values between 50 and 180 mm and the peak flows rates were comprised between 5,87 and 355 m^3/s.

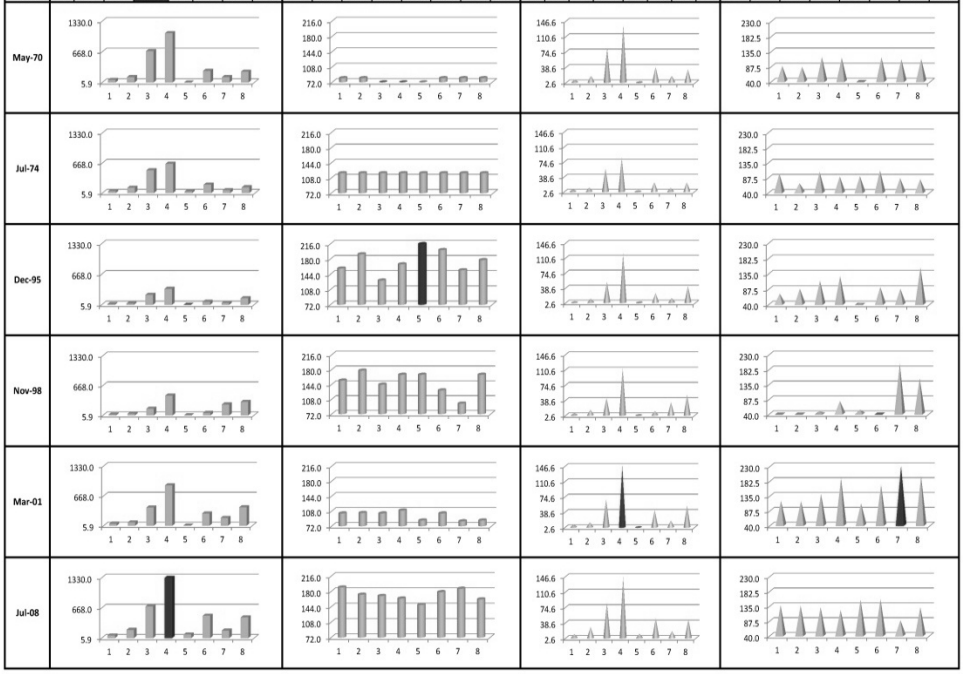
November 1998. The climate evolution from November 1998 led to a pluvial flood between the 3rd and the 9th of November. It all started during the second half of October which was characterized by a significant fluctuation, from positive temperatures to temperatures under 0 degrees towards the end of the month. At altitudes over 1000m in the basin there has been recorded a layer of snow which sometimes exceeded 22cm depth. The precipitations which fell on October 1998 have exceeded the normal values of the month, therefore the ground was completely saturated with water. A first flood was recorded after the rainfalls of October 29, followed by a second one produced by heavy rainfall which together with the layer of snow have had values comprised between 16 and 199 mm. Thus, Vișeu river basin has recorded peak flows comprising values between 446 m^3/s (Vișeu-Bistra) and 9,1 m3/s (Țâșla – Baia Borșa), exceeding the probability of 2% within Ruscova basin.

March 2001. During the first half of March 2001 a significant pluvio-nival flood has been recorded in Vișeu river basin, the second largest after the one in 1970, in terms of the recorded peak flows and levels. The period between the 20th of February and the 1st of March was characterized by the successive evolution of some depression areas installed near the polar seas up to the Mediterranean Sea basin. These have determined through the N-W pervasion of polar maritime air masses a period of lower temperatures, clouds and heavy snowfall. Snowfall has formed in the basin a new layer of snow of an average of 20 cm depth and the water reserve accumulated within the layer of snow was measuring 91,0 mil.m^3 *(Cocuț, 2008).* Starting with the 1st of March the weather was considerably warmer due to the advection of the warm and humid air coming from the Mediterranean Sea. The maximum air temperature has increased significantly and steadily reaching positive values. The rainfalls during the 2nd and the 6th of March have presented an irregular spatial distribution with values between 230 mm and 110 mm. As a consequence to the previous rainfalls the value of the peak flows of the flood were comprised between 14,0 m^3/s at Baia Borșa on Vișeu and 902 m^3/s at Bistra on Vișeu, with overflow probabilities of 1,2% at Ruscova basin. The flood volumes have recorded values between 1,53 mil. m^3 at Baia Borșa and 116,152 at Bistra.

July 2008. The main cause of the flood was the climate, the genesis of the flood being totally a pluvial one. On the 20th and the 22nd of July 2008, a part of the extremely humid atmospheric front which affected Transylvania, Crișana and Maramureș has crossed the space between the Carpathians and the Balkans arriving

over the Black Sea and reloaded with humidity. The movement of the front became in this way retrograde, transitioning from W-E to SW-NE, S-N, SE-NW, affecting the northern part of the Oriental Carpathians (*Hociug, 2010)*. The synoptic situations of the 22nd -27th July describes a Scandinavian thalweg which formed a cold stationary nucleus generating torrential rainfalls over large areas of Romania, especially in the northern side of the country, in the Oriental Carpathians. The estimated heavy rainfalls in Vișeu river basin during this period were comprised between 120 – 240 mm, and even more, the rainfalls' volume exceeding the monthly average (in 6 days it rained three times more than in a normal month of July). Therefore, the water evolution in these areas was characterized by producing in just 2-3 days several concomitant extremely violent floods in the main sub-basins of Vișeu river. These floods were propagated on Vișeu river, some hydrometric stations recording historic flows. The total duration of the flood was of 164 hours, reaching a peak flow of 1330 m^3/s on the 27th of July at 01:00 am at Bistra station. The psychological impact of the flood was even greater when its peak level and flow was reached during the night on most of the main streams.

	Q max (m3/s)								T total (h)								V total (mil. m3)								hp (mm)							
	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8
May-70	62.0	124.0	684.0	1072.0	0.0	257.0	124.0	240.0	82.0	82.0	72.0	72.0	0.0	82.0	82.0	82.0	9.1	17.9	83.4	136.8	0.0	38.8	17.9	32.7	88.1	85.1	116.0	113.9	0.0	115.0	109.0	110.0
Jul-74	48.1	123.0	508.0	651.0	42.0	192.0	69.3	134.0	120.0	120.0	120.0	120.0	120.0	120.0	120.0	120.0	8.3	12.3	57.9	83.6	6.0	25.7	11.4	24.9	99.3	68.8	104.6	90.4	91.8	109.2	85.2	81.6
Dec-95	20.5	34.0	224.0	355.0	5.9	72.4	49.8	151.0	158.0	192.0	130.0	168.0	216.0	202.0	154.0	178.0	5.8	11.7	52.7	120.9	3.0	25.2	13.3	42.5	72.3	87.8	112.5	127.1	43.5	93.0	87.3	153.1
Nov-98	26.4	42.9	156.0	446.0	9.1	61.3	250.0	307.0	154.0	178.0	144.0	168.0	168.0	130.0	98.0	168.0	7.5	15.5	44.2	113.9	3.2	12.3	33.5	51.1	16.3	40.1	46.7	80.5	52.5	40.0	199.2	152.8
Mar-01	53.6	80.0	411.0	902.0	14.0	280.0	181.0	417.0	103.0	104.0	103.0	110.0	86.0	103.0	84.0	86.0	9.1	13.9	68.4	146.6	2.6	42.8	18.1	53.4	118.0	117.0	140.0	192.0	110.0	169.0	230.0	198.0
Jul-08	63.9	187.0	704.0	1330.0	86.0	497.0	171.0	462.0	190.0	173.0	170.0	164.0	149.0	179.0	187.0	162.0	11.7	28.2	85.1	145.8	12.2	49.2	18.4	46.2	137.0	135.9	130.4	121.4	154.4	156.5	88.6	130.4



LEGEND

1 - Poiana Borșa hydrometric station - Vișeu River; 2 - Moisei hydrometric station - Vișeu River; 3 - Leordina hydrometric station - Vișeu River
4 - Bistra hydrometric station - Vișeu River; 5 - Baia Borșa hydrometric station - Țâșla River; 6 - Vișeu de Sus hydrometric station - Vaser River;
7 - Luhei hydrometric station - Ruscova River; 8 - Ruscova hydrometric station - Ruscova River

Fig. 2. ***The comparison of the most significant flash floods in Vișeu river basin***

4. THE EFFECTS OF THE SIGNIFICANT FLOODS

A flood involves a series of functions that jeopardizes the area in terms of different points of view, representing a geomorphological, environmental, social and economic risk factor which shapes the entire natural and anthropic environment.

Geomorphological risk. Flash floods have contributed to the modification of the floodplain through: surface and torrential erosion, lateral erosion, sediment transport, changes of the floodplain both transversally and longitudinally, modification of terraces and soil horizon composition, changes of courses of rivers. Along with the emergence or acceleration of these geomorphological processes the infrastructure, the buildings and the civil structures arranged in the floodplain are jeopardized.

Environmental risk. The most significant environmental effects on the surface waters of Vișeu river basin make reference to the negative impact on the water quality and soil fertility. Such an unpleasant case occurred during 2000, after an increase in water flows in Novăț basin, tributary of Vaser river, within the tailing dams used not long ago by Baia Borșa mine, a gap appeared through which 20000 tons of solid material flowed, therefore polluting the waters of the tributary. The waters flooded large surfaces of agricultural land, and according to the statements of several locals, the ground was reintroduced in the agricultural process only after 5 years from the incident. Also due to the alluvium carried by the dark waters, the wells of the locals were clogged thing that required the help of the authorities in order to ensure drinking water in the affected area.

Social risk. In addition to the damage that can be assessed, the floods have had a series of unquantifiable negative social effects, which cannot be evaluated in an economic indicator. Among these negative effects, the most unfortunate is the loss of human lives. During the assessed period, 1970 – present, six deaths occurred. Due to the precarious conditions (humidity, cold etc.) where the affected population was located, predispositions to certain diseases has increased, some of the chronic becoming acute both as a result to the prolonged efforts of the population during the intervention periods and damage recovery, and as well as due to the anxiety and the stress created by these efforts. Another negative outcome of the floods was the diminishing of the incomes and the interruption of certain cultural and educational activities.

Economic risk. The economic damage caused by the floods consisted of the damaged or destroyed infrastructure due to its location in the floodplain (houses, roads, bridges, railroads, households, urban infrastructure etc.). This category also includes industrial facilities with materials or raw materials warehouses, agricultural or zootechnical facilities which have recorded production and animal losses if these could not be evacuated from the affected area. The following table presents the economic damage caused by the significant flash floods in the period between 1995-2005 of the entire Vișeu river basin. The damage that affected socio-economic activities resulted in the unavailability of

electricity networks, drinking water, as well as the untapped agricultural lands (nearly 5000 ha) *(Cocuț, 2008)*.

Table 2. ***Damages caused by floods during 1995-2005 (sourse: Cocuț, 2008)***

Flash flood	Animals (no.)	Houses (nr.)		Housedold annexes (no.)	Infield (ha)	Street network (km)	Roads (km)		Bridges (no.)	Econ. object. (nr.)	Value ($)
		damaged	destroyed				local	county			
Dec-95	-	91	-	261	1069.85		48.56	0.1	16	5	180629
Nov-95	-	190	-	209	-	1.12	13	1.3	51	5	2795189
Mar-00	-	-	-	1133	-	-	40.1	27	15	2	374579
Apr-00	-	-	-	-	1723	-	15.97	-	26	3	779151
May-01	90	367	18	475	2181.5	92.25	1.5	22.45	211	-	849317
Total	**90**	**648**	**18**	**2D78**	**4974.35**	**93.38**	**119.13**	**26.55**	**319**	**15**	**6633363**

The major losses were created by the historic flash flood from 2008. The most affected area was the one of Vaser basin. According to the statements of the town hall of Vișeu de Sus, after a first assessment the total value of the damage produced by the flood amounted to 40 mil. lei. The balance of the damage resulted in the total destruction of four households, 9 homes affected in a large proportion and another 69 affected in a smaller proportion. The restoration of these houses was financed by budgetary allocations through governmental decisions amounting to a total value of 255 thousands of lei.

Damage to transport infrastructure and railroads was produced and electricity networks and power supply equipment were destroyed. Novicior, Novăț and Roșu bridges were damaged or destroyed, as well as footbridges and rural and forestry roads. Around 250 houses were isolated on Scradei Valley, towards Plaiului bridge, 200 houses on Rea Valley and about 100 on Peștilor Valley totaling a number of approximately 1700 inhabitants.

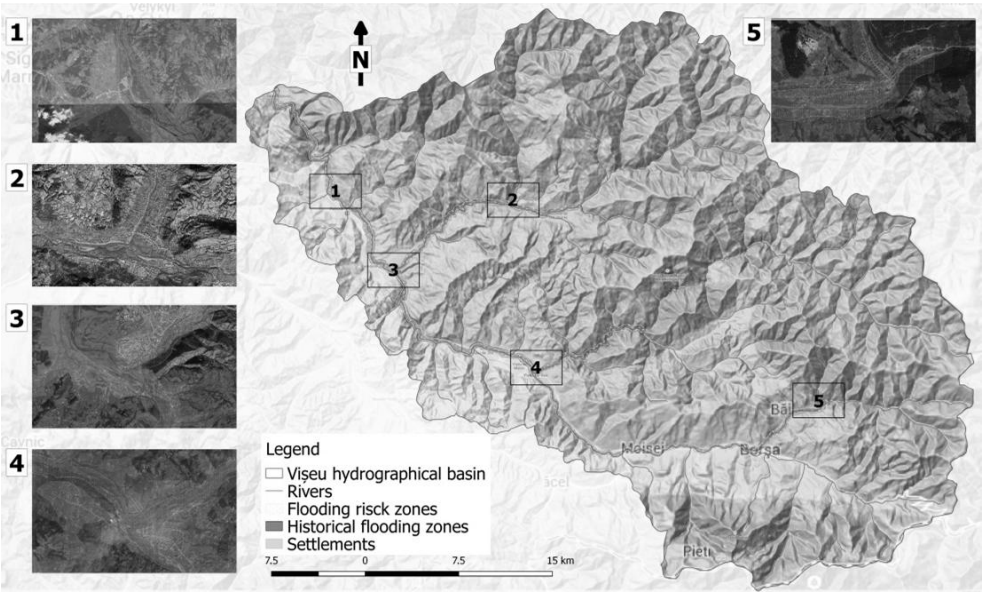


Fig. 3. ***The flooding risk/historical flooding zones (source: INHGA, Google Maps)*** **.**

Fig. 4. ***The effects of Vaser floods, 2008 – A)The forest railroad train; B) Făina Camping; C) Novăț bridge; D) Vaser floodplain; (Foto: www.emaramures.ro, 2008; Michael Schneeberger, 2011).***

5. CONCLUSIONS

Analyzing the series of floods since 1970 up until the present time at Bistra station, the last one on Vișeu river before the confluence with Tisa, a significant frequency of floods has been observed, a flood every 4,5 years between the period 1995-2008. There also can be observed a tendency of increase of the recorded peak flows, therefore leading to severe repercussions on the environment. An important cause of this tendency is the intense anthropic activity which has a boomerang effect on the environment in the Vișeu river basin.

The population of Vișeu river basin is extremely exposed due to the concentration of settlements around the floodplain and unfortunately due to the lack of complex hydrotechnical facilities nothing can be done in order to diminish the flows and to avoid damage caused by floods. The authorities are pleased at the moment with the help of human intervention and assistance and activities for temporary avoidance of negative effects.

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