Forum geografic. Studii și cercetări de geografie și protecția mediului
Volume XV, Issue 1 (June 2016), pp. 25-33
http://dx.doi.org/10.5775/fg.2016.116.i

Exceptional floods in small basins in North-Western Romania and the induced effects – Bârsău River, Maramureş county

Gheorghe ȘERBAN[1,*], Sorin Ionel RÂNDAŞU-BEURAN[1], Ioan ROŞU[3], Simion NACU[2], Daniel SABĂU[1], Andrei NIŢOAIA[1]

[1] Babeş-Bolyai University, Faculty of Geography, 5-7 Clinicilor Street, 400001, Cluj-Napoca
[2] Romanian Waters National Administration, 6 Edgar Quinet Street, 010018, Sector 1, Bucharest
[3] Romanian Waters National Administration - Someş-Tisa Water Branch, 7 Vânătorului Street, 400213, Cluj-Napoca
* *Corresponding author*, serban@geografie.ubbcluj.ro

Received on <03-06-2016>, reviewed on <15-06-2016>, accepted on <19-06-2016>

Abstract

The study aims to analyse floods from May 1970, June 1974 and May 2015, which occured in the Bârsău catchment area, one of the right tributaries of the Someș River. The junction between these two rivers is downstream of Satulung locality in Maramureș County. Bârsău catchment area is located between the Someș and Lăpuș catchment areas and has a surface of 152 km^2. The floods of the Bârsău River are fast and have a very short propagation time. They are caused both by rainfalls and snow melting. This is the case of the flood from May 1970, which had a duration of two days, whereas the floods from June 1974 and May 2015 occured just because of heavy rainfalls. From the three analyzed floods, the May 2015 flood, with a pluvial origin, reached the maximum level of 220 cm (DL+20 cm) at Buciumi gauging station and its effects strongly affected local people. Thus, the damages in the villages located inside the basin were recorded first, then quantified. After that, there were made the integrating maps of the flood prone areas as well as the hydrological and associated risks in order to identify areas with different degrees of vulnerability.

Keywords: *flash-flood, maximum discharge, maximum level, Bârsău, flood effects*

Rezumat. Inundații excepționale în bazinele mici din nord-vestul României și efecte induse – râul Bârsău, județul Maramureș

Studiul își propune să analizeze inundațiile din mai 1970, iunie 1974 și mai 2005 care au avut loc în bazinul hidrografc al râului Bârsău, unul dintre afluenții de dreapta ai râului Someș. Confluența celor două râuri se află aval de localitatea Satulung din județul Maramureș. Bazinul hidrografic Bârsău este localizat între bazinele Someșului și Lăpușului, având o suprafață de 152 km^2. Inundațiile produse de râul Bârsău sunt rapide și prezintă un timp scurt de propagare. Totodată, sunt cauzate atât de precipitații, cât și de topirea zăpezilor. În acest fel s-au produs inundațiile din mai 1970, cu au avut un timp total de două zile, spre deosebre de iundațiile din iunie 1974 și mai 2015 care s-au produs doar pe fondul precipitațiilor abundente. La nivelul celor trei studii de caz, inundațiile din mai 2015, cu origine pluvială, au atins nivelul maxim de 220 cm (CP+20 cm) la stația hidrometrică Buciumi,iar efectele au influențat puternic populația locală. Astfel, pagubele din satele localizate în interiorul bazinului au fost mai întâi înregistrate și apoi cuantificate. Ulterior, s-au realizat hărți de integrare a zonelor inundabile, a riscurilor hidrologice și asociate cu scopul de a identifica arealele cu diferite grade de vulnerabilitate.

Cuvinte-cheie: *viitură, debit maxim, nivel maximum, Bârsău, efecte ale inundațiilor*

Introduction

Flash-floods in literature

Floods study, especially that of flash-floods, regarding the effects induced by the phenomenon, was a priority for many scientists since Ancient times because of the natural disaster`s amplitude and the immense tangible or intangible economic and social damages.

A flood is a sudden and significant increase and diminution of the level and discharge values of a river, that also represent one of the most dramatical relation between man and environment, emphasized by the natural phenomenon amplitude and also by man`s difficulties to control it (Ward, 1978).

Floods are caused by both natural and anthropogenic factors, most fluvial floods being produced directly or indirectly by atmospheric events such as intense rainfall, sudden melting of snow due to a heat wave in the cold period of the year. If the rainfall is overlapping a snow layer and a frozen soil, the consequences can be catastrophic.

The damages caused by floods include a wide range of harmful effects on people's health, and their goods, public infrastructure, cultural heritage, ecological system, industrial production system and competitive power of local economy (Messner & Meyer, 2006). Absolute protection is impossible to achieve and also unsustainable, due to high costs and the inherent uncertainties. Therefore, the management of the flood-related risk is more appropriate (Schanze, 2006; Schanze et al., 2006).

In many regions of the world, floods are some of the most destructive natural hazards, often resulting in a large number of deaths and material losses. It is found that approximately 40% of deaths due to floods in Europe from 1950 to 2006 are related to the phenomenon of flash-flood (Barredo, 2009; Lumbroso & Gaume, 2012). Floods of this type are caused by the falling precipitation in liquid form in a very short time, with a very high intensity on a small area.

As Gaume et al. (2009), Marchi et al. (2010), Ruiz-Villanueva et al. (2012) say, at the European level there can be observed a spatio-temporal difference regarding the distribution of flash-floods. Thus, in the Mediterranean area (Italy, France, Catalonia), an increase of its strength is obvious during the autumn, while in continental regions (Romania, Slovakia, Germany, Austria) flash-floods generally occur during the summer.

In Romania, the largest disasters due to floods occurred in 1926, 1970, 1975, 1991, 2005 and 2010. Considering the number of deaths in 1926 (1000 deaths) it can be said that floods represent the second disaster in the recent Romanian history after the earthquake of 1977, when 1641 deaths were registered. Moreover, the recent floods in 2005, along with the 1977 earthquake, represent the most significant natural disasters in the history of Romania also because of the material damages recorded, which have been estimated at 2 billion USD for each event.

In the last decade, the frequency of floods has grown, these generating damages of 5 billion USD, which means an annual average loss of 483 mil USD. Almost half of the amount has been generated by the floods of 2005, the number of victims from this period being 208 (Senzaconi et al., 2010).

Study area and general information relating to analyzed floods

The Bârsău River (Fig. 1) has a length of 34 km and it is a right tributary of the Someș river. It springs at an altitude of 550 m in the vicinity of Vărai village (Valea Chioarului commune) and flows into the Someş collector at an altitude of 152 m on the territory of Satulung commune in Maramureş County.

The water catchment area, located between the Someș and Lăpuș water courses, overlaps almost entirely the Chioar Hills (Posea, 1980; Panda, 1980). The drained surface is about 152 km^2, and the average altitude is 317 m (Water Cadastre Atlas from Romania, 1992).

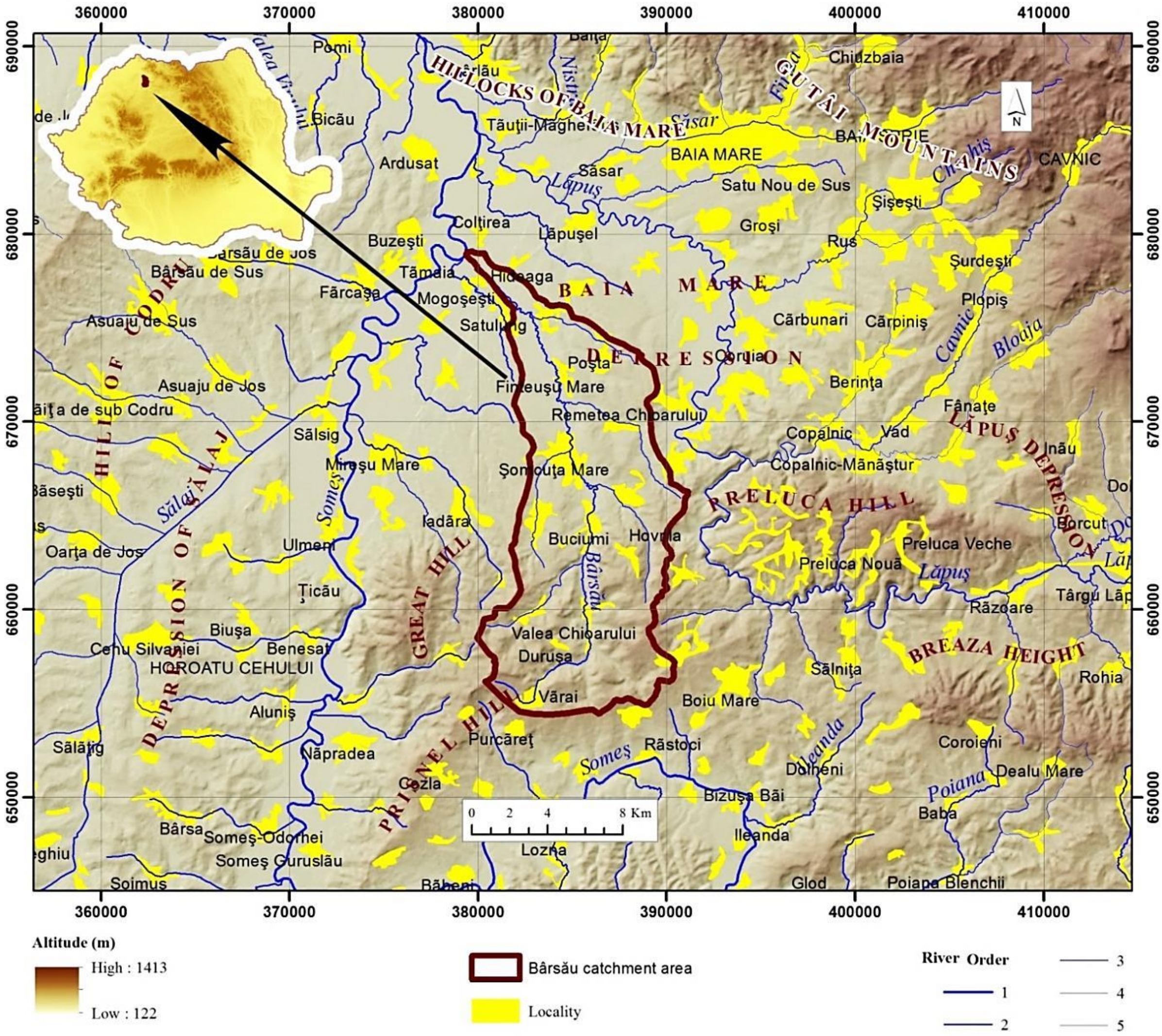

Fig. 1: The Bârsău River basin location in relation to the relief units

Forum geografic. Studii și cercetări de geografie și protecția mediului
*Volume **XV**, Issue **1** (**June 2016**), pp. **25-33***
*http://dx.doi.org/**10.5775/fg.2016.116.i***

The Bârsău River has five main tributaries: two left tributaries - Curtuiuş-7 km, Căicana-8 km and three right tributaries – Ciolt - 8 km, Berchezoaia - 10 km and Poșta - 7 km, the last one being the main collector of Chioar Hills.

The frequency and magnitude of floods on the Bârsău River are caused not only by natural factors, but also by anthropogenic factors. The most frequent floods are caused by meteorological factors such as: both torrential and long-lasting rains, as well as snow melting overlapped with significant quantities of rainfalls.

In the Bârsău catchment area, the water flow monitoring and the observations related to the hydrological regime variations of water drainage were made just until the end of 2003 at Satulung hydrometric station. It was removed due to that being located downstream of this locality, the station was not able to issue warnings for the Şomcuta Mare town. In the year 2003, it was achieved a new station on the Bârsău River, upstream of the town, in Buciumi village. The hydrometric station was given into service from January 1, 2004, and since 2007 it has been equipped with automatic monitoring and transmitting equipment.

The threshold defence levels of the Buciumi gauging station are: AL = 80 cm, FL = 130 cm and DL = 200 cm. An important remark is that Buciumi hydrometric station has an extraordinary transmission (not daily), transmitting data only when water levels overpass the attention level.

At Satulung gauging station, two major floods were noted: the first in May 1970, when it reached a maximum level of 449 cm (FL+149 cm) and the second in June, the 2nd, 1974, when it reached a maximum level of 430 cm (FL+130 cm). The flood from 1974 was more destructive than the one from May 1970, although the level was 19 cm lower; the river's water flow was higher due to the alteration of hydraulic parameters of the river bed in the gauging station sector (WMS Archive, 1974).

After moving the station in Buciumi village, upstream from Şomcuta Mare town, there have been recorded two major floods, the first on March 25th, 2005, when it reached a maximum level of 156 cm (FL+26 cm) and a flow rate of 28.4 m^3/s. The second flood occurred in May 27th, 2015 when it reached and exceeded the danger level, the maximum level of the flood being 220 cm. It corresponds to a reconstituted water flow of 37.5 m^3/s, being the second water discharge value recorded.

The hydrologists from WMS Maramureş have reconstituted the water flow for the flood that occurred in June 2nd, 1974, for Buciumi section, resulting in a water discharge of 80.6 m^3/s (Synthesis Report May 2015, WMS Maramureș). This is the historical maximum flow drained in Buciumi section.

Database and Methods

The database used in this analysis consists both in hydrological and meteorological data, taken from the Water Management System`s archive, Maramureș.

For the creation of the cartographic material, topographic maps at a scale of 1:25,000 and licensed GIS software from the two institutions involved in this study, namely: Babeş-Bolyai University, Cluj-Napoca, Faculty of Geography and "Romanian Waters" National Administration, Bucharest were used.

The study of the occurrence conditions and the characteristic elements of the flood was based on the data and the conclusions drawn up by the specialist departments of Someș-Tisza Regional Water Branch and ”Romanian Waters” National Administration.

The evolution data of the water level and flow of the Bârsău River were processed with CAVIS, whereas the cartographic representations were obtained using the ArcMap 10.x software.

The methods used in the research, processing and analysis were: the observation method, graphic-analytical method, deductive method, statistical method and the cartographic method, with analogue and digital application.

Catchment area`s exposure and position

The floods that occur within the Bârsău basin are frequently generated by abundant rainfalls, often heavy rains or sudden snow melting. Usually, after overrunning the attention level (AL), the maximum level is reached in a very short time and within 2-3 hours, the river level is decreasing below attention level.

Slope exposure towards the general circulation of air masses

Its location in the path of moist air masses with a predominantly Western advection, located at the footsteps of the Gutâi Mountains ascension causes significant amounts of rainfalls for the Bârsău basin (Fig. 1). The multiannual values are high, more than 800 mm in the North-Eastern part of the basin (The Baia Mare Depression and the vicinity of Gutâi Mountains) and low (slightly over 700 mm) specific for the Eastern and South-Eastern extremity, where atmospheric fronts are reactivated by the crystalline massif of Dealul Mare -Țicău.

The influence of the catchment area`s shape

The shape of the hydrographical basin is an analytical expression with conventional character (Vladimirescu, 1984), which highlights the character of circular or oblong basin and it is determined as the ratio between the area of the basin and the length of the watershed. As it is closer to circularity, the accumulation of flood on the slope in the center spot will be faster and it will propagate a larger water volume in the river bed (Fig. 2).

Assessment of the basin`s shape can be done both in quantitative and qualitative terms. A quantitative assessment of the shape of the basin shall be made on the basis of formulas in which the shape of the basin is compared with a reference geometric shape.

For the quantitative evaluation, several authors have proposed a number of indicators, of which we remember those mentioned by Sorocovschi and Șerban, 2012:

- *form factor* (R_f): this is the ratio between the surface and the square maximum length of the basin (Horton, 1932);
- *the circularity ratio* (R_c) is the result of the division between the surface of the basin and the surface of the circle with the length equal to the perimeter of the basin (Miller, 1953);
- *elongation ratio* (R_l) is the result of the division between the circle with the diameter equal to the surface of the basin and the maximum length of the basin (Schumm, 1956);

Rădoane et al., 2006; Zamfir & Simulescu, 2011 and Nițoaia et. al., 2016, use the coefficient of circularity to determine the shape of the basin, calculated according to the formula:

$$C = \frac{Lc}{2\sqrt{\pi F}}$$

where: C – circularity coefficient,

Lc – watershed length (perimeter - km)

F – total area of the basin (km^2)

The value of the coefficient of circularity, C, is dimensionless, C ≥ 1, but the closer it is to unity, 1, the shape of the basin is closer to circularity.

For the studied basin, the surface was determined using ArcMap 10.x software generating two new columns in the attribute table of the basin, where the area and perimeter were calculated. These two parameters were used subsequently for the determination of circularity coefficient. After a quantitative assessment over the shape of the basin was made, the coefficient graphical represention was achieved. Thus, Bârsău basin (Fig. 2) with a coefficient of 2.41, has an elongated shape, although in its upper compartment the widening is obvious.

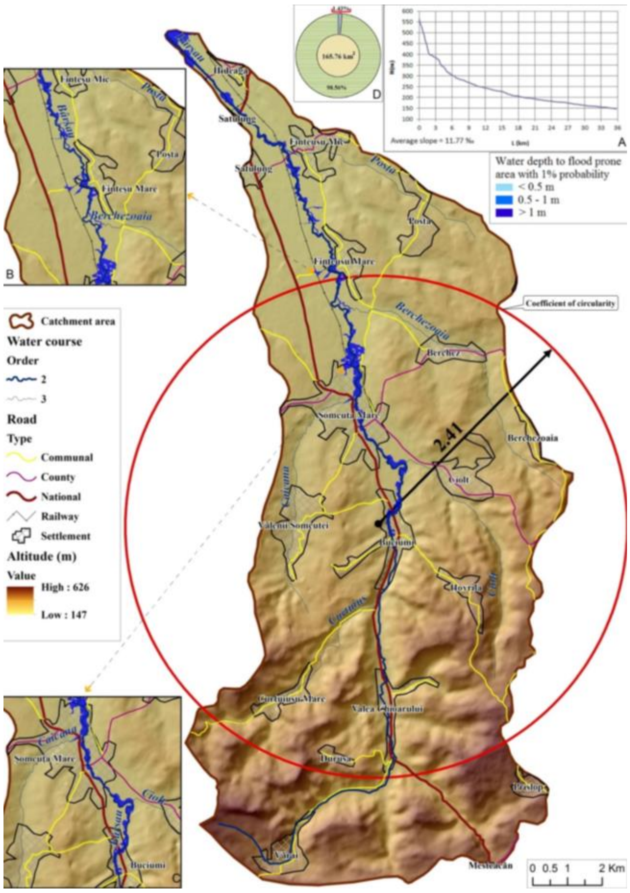

Fig. 2: Coefficient of circularity map overlapped on flood prone area at 1% probability of liquid flow. A, Longitudinal profile; B, Settlements exposed to floods; C. The Town most exposed to floods

Floods features

May 1970 flood

In Maramures County, the flood was formed as a result of significant quantities of rainfalls in a short time (at Baia Mare there were recorded 121.2 mm in 13.05.1970) and the sudden snow melting (WMS archive, 1970).

In a period of 48 hours (11-13 May, 1970), in the Eastern and Northern Transylvania and in Maramureş, including the Bârsău basin, the recorded rainfalls were more than 50 mm, and in some areas, even over 100 mm (Table 1).

Table 1: Rainfalls recorded in 12-15 May 1970 period within Bârsău catchment area

Meteorological/ Gauging Station	Altitude (m)	Day/Precipitation (mm)				
		12			12	
Șomcuta Mare	200	7.3	120.8	128.1	6.5	4.2
Ardusat	160	4.8	75.2	80.0	5.0	8.0
Baia Mare	198	7.2	121.2	128.4	6.2	5.9
Seini	145	16.5	140	156.5	28.0	16.0
Ulmeni	165	8.0	59.6	67.8	3.5	0.0
Jibou	198	31.6	31.3	62.9	3.8	0.1

Although Figure 3 graphically presents the distribution of the rainfalls recorded in May 12-14, 1970 period throughout the country. These rainfalls fell across a soaked and frozen soil (in the mountain areas). Moreover, at higher altitudes a consistent snow cover was present, thicker than 110 cm, accumulated in the previous months. The major quantitative rainfall added water quickly restored by the layer of snow and a low evaporation rate, under

Forum geografic. Studii și cercetări de geografie și protecția mediului
*Volume **XV**, Issue **1** (**June 2016**), pp. **25-33***
*http://dx.doi.org/**10.5775/fg.2016.116.i***

some cold temperatures. The drainage coefficient had high values (0.7), the water flow of the rivers reaching record values. It was a flash-flood which produced an inundation with disastrous effects on the riparian settlements of the Bârsău and its collector, Someș. On Bârsău river, flood started on May 13th at 01:00 AM, when water spilled out from the minor river bed at the Valea Chioarului village and finished in May, 14th at 6:00 PM, when the water retreated. At Valea Chioarului village, the flood peak was recorded on May 13th at 05:00 PM, and on May 14th at 05:00 PM, the waters have receded. The damages recorded in this settlement are smaller (it is located in the upper basin), except for the large surfaces of agricultural terrains flooded after the overflow.

Fig. 3: Rainfalls from 12 to 14 May 1970

In Șomcuta Mare settlement, the Bârsău river spilled out on May 13th, 1:30 AM, and the flood peak was recorded on May 13th at 03:30 PM. The damages were very important and were caused by the Bârsău river overflow flooding and its tributaries, and also by the runoff on slopes (the settlement is situated at the exit of the water courses from the upper sector of the basin, in a"water gathering piazza" - Fig. 2). Șomcuta Mare, Buciumi, Fințeușul Mare settlements were partially flooded, whereas in Satulung commune, Fințeușul Mic and Satulung villages were affected.

In the Satulung locality, Someș collector waters receded only in May 18th, 1970 at 11:00 PM in the conditions of a consistent intake from the upstream. The flood of the Bârsău River in May 1970 had a single peak (maximum discharge value), the highest level reached at the Satulung gauging station was 449 cm (FL+149 cm), achieved on May 13th, 1970 at 06:00 PM.

June 1974 floods

In June, on the Bârsău river there have been five flash-floods, the amplitudes of which reached outstanding values of the water flow and levels. Their defining character trait was the succession and the increase of the maximum level up to flooding level (FL), which made it impossible to rehabilitate the anthropic and natural environment for a long period of time (about a month).

The first and most important throb occurred on the 2nd of June 1974 and was caused by exceptional rainfall quantities recorded in the area. At Șomcuta Mare, in June the 2nd, 1974 between 02:00-08:00 AM, 137 mm were recorded, although the precipitation rate per 24 hours with 1% insurance is approximately 80 mm/m^2/24 hours. The flood that took place was more destructive than the one in the 1970s, although the maximum level recorded was 430 cm (FL+130 cm), 19 cm lower than the level recorded in May 1970.

The second flood occurred in June 7 when the level came close to flooding level, 299 cm (FL-1 cm). Between the 11th-15th of June, *the third flood occured*, which reached a maximum of 400 cm (FL+100 cm). *The fourth flood*, June 25th, had a maximum level of 320 cm (FL+20 cm). The last flood occurred in June 30th and had a maximum level of 330 cm (FL+30 cm). Although on the Someș collector the flood`s magnitude was smaller than the one in March 1970, on a neighbouring water course, Sălaj Valley, (Fig. 1) the levels and flow values were overcome.

May 2015 flood

It is the first important flood produced after the gauging station`s replacement from Satulung to Buciumi, upstream from the Șomcuta Mare town.

During the night of May 26-27, 2015 in the Southwestern part of Maramureș County, important heavy rainfall quantities were recorded. Most of the rain fell between 03:00 and 05:00 AM, when some areas reached 60 l/m^2, but these values were exceeded in the watershed area between the Someș and Bârsău, respectively Bârsău and Iadăra basins (Fig. 4). Valea Chioarului and Șomcuta Mare localities related within the Bârsău basin were also affected. Table 2 presents the amount of rainfalls reported on May 27th, 2015 and the precipitation thresholds.

Table 2: The 24 hours amount of rainfall measured in May 27th, 2015, 6.00 AM (according to "Romanian Waters" National Administration)

No.	Gauging station	River	Precipitation	Threshold (mm)	Gauging station
1	Sălsig	V.Sălajului	76.4	60	03-05
2	Cicîrlău	Someş	55.9	51	03-05
3	Ulmeni	Someş	55.7	38.7	03-05
4	Lăpuşel	Lăpuş	30.7	28.6	03-05
5	Buciumi	Bârsău	24.5	-	-
6	Rastoci	Someş	71.0	-	-

When analyzing the map (Fig. 4), it is obvious that the clouds with maximum rainfall intensity followed the Someș Corridor, both to the East and

North, likely diverted by Prisnel and Dealul Mare crystalline peaks. Thereby, these clouds` route led to the cover of Bârsău upper sector, with massive lightning in the highest area, where heavy drainage is formed. The maximum flow recorded at the Buciumi gauging station was 55 m^3/s, produced on May 27, at 09:00 AM GMT, even if the flood started from a basic flow of 0.058 m^3/s!

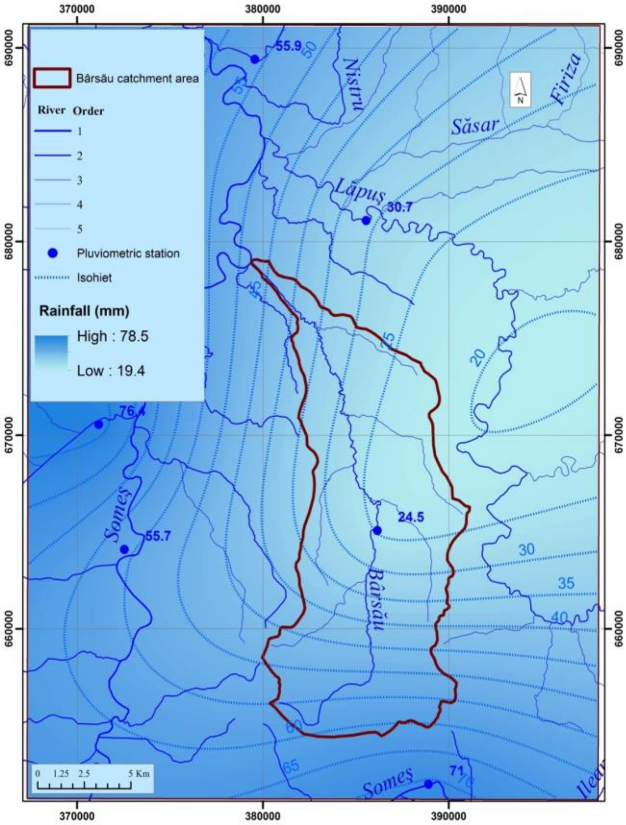

Fig. 4: Spatial repartition of 24 hours amount of rainfall measured

The total duration of the flood was 29 hours, from which the increasing time was 14 h (Fig. 5). The total volume of the flood was 1.82 million m^3, with a base volume of 1.64 mil m^3, with a 12 mm runoff layer, and a form coefficient of 0.31. The water level at a maximum flow of 55 m^3/s has reached 220 cm, overrunning by 20 cm the *danger level* (DL).

The effects of the floods

May 1970 flood`s effects

During the flood of May 1970, Valea Chioarului, Șomcuta Mare (Șomcuta Mare, Finteușul and Buciumi) and Satulung (Satulung and Finteușul) communes were affected by the overflow of Bârsău and its tributaries. The damage from May 1970 flood totalled 4028 thousand RON, the most affected locality being Șomcuta Mare (about 75%), 25% being recorded in the Satulung village, flooded by both the Someș and Bârsău rivers. At the Valea Chioarului locality, the damages were approximately 0.57% of total (Fig. 6), without any casualties.

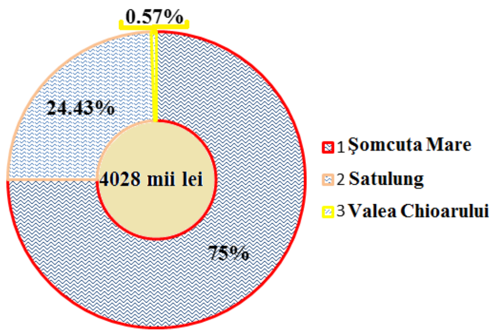

Fig. 5: Damages recorded in Valea Chioarului, Șomcuta Mare and Satulung localities during the May 1970 flood

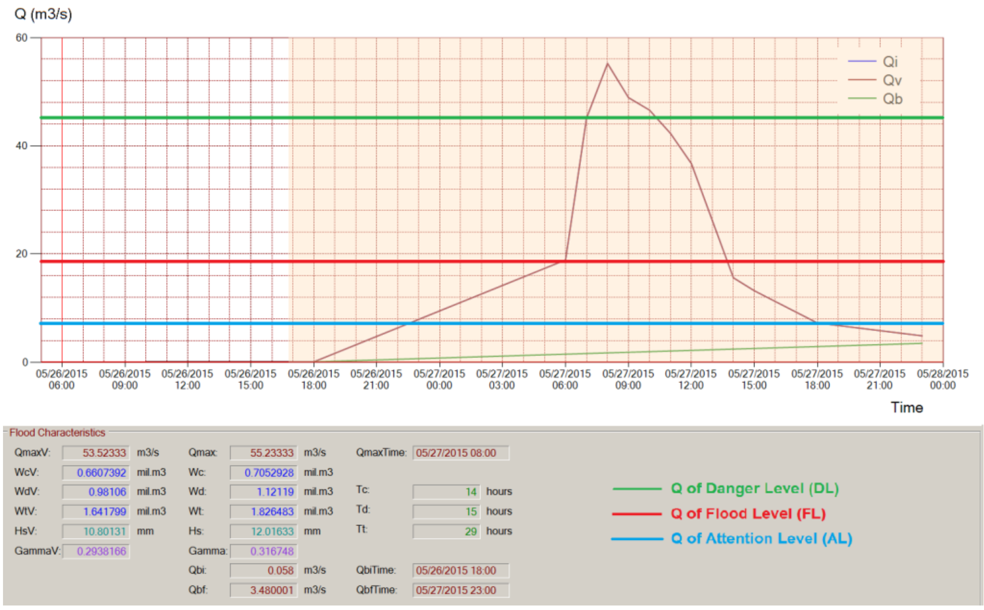

Fig. 6: Flood hydrograph to Buciumi hydrometric station, Bârsău River, realised with CAVIS software (Corbuș, 2006)

The recorded damages in Valea Chioarului refer to 0.57 km^2 of flooded agricultural terrain.

In Șomcuta Mare, the following categories of damages were recorded: 2 houses destroyed, 5 houses damaged, 1.5 km of paved road destroyed, 2 km of paved road damaged, 6 km of causeway damaged, 3 bridges destroyed, 2 bridges damaged, 10 footbridges destroyed, 5 footbridges damaged and 0.5 sqkm of agricultural terrain were flooded.

In Satulung locality the following categories of damages were recorded: 27 houses destroyed and 12 houses damaged, 13 other constructions destroyed, 7 other construction damaged, 2 km of causeway damaged, 3 bridges destroyed, 2 bridges damaged, 18 footbridges damaged, 9.23 km^2 of agricultural terrain, 2 dead animals.

June 1974 flood`s effects

As a result of this hydrological risk phenomenon, no human victims were recorded, only material damages. Thus, in the Valea Chioarului village the following damages were recorded: 2 houses flooded, 1 house destroyed, 1 other building destroyed, 1 bridge destroyed, 5 footbridges destroyed, 0.25 km2 of agricultural terrain flooded.

In Șomcuta Mare locality the following damages were recorded: 24 houses flooded, 7 houses destroyed, 12 houses damaged, 15 other constructions flooded, 15 other construction damaged, 1.5 km of paved road damaged, 14 km of causeway damaged, 5 bridges destroyed, 2 bridges damaged, 20 footbridges destroyed, 4.5 km^2 of agricultural terrain flooded, 0.02 km^2 of landslides, 4 economic agents flooded, 4 economic agents damaged and 5 dead animals.

In the Satulung locality the following damages were chronicled: 9 houses flooded, 9 houses damaged, 6 other building flooded, 2 other building destroyed, 2 other construction damaged, 1.1 km of causeway damaged, 3 bridges destroyed, 3 bridges damaged, 7 footbridges destroyed, 10 footbridges damaged, 4.8 km^2 of agricultural terrain flooded, 2.05 km^2 agricultural terrain destroyed by landslides, 0.5 km electrical lines destroyed an also 0.5 km of phone lines has been destroyed. For the June 1974 flood, there are no recordings on the value assessment of damages, only physical references.

May 2015 flood`s effects

May 2015 flood affected Șomcuta Mare commune (Șomcuta Mare, Buciumi, Finteușu and Vălenii Șomcutei) and Valea Chioarului (Valea Chioarului, Curtuiușu Mare, Durușa, Mesteacăn, Vărai and Fericea) in the Bârsău catchment area. Within the Someș basin and other adjacent tributaries, Ulmeni, Mireșu Mare, Fărcașa, Ardusat, Cicîrlău and Asuajul de Sus localities were affected, while in the Lăpuș basin Sisesti and Remetea Chioarului villages were affected. Due to the slope`s runoff and the overflow of Bârsău tributaries, many localities were affected (Șomcuta Mare, Buciumi, Finteușu Mare, Curtuiușu Mare and Valea Chioarului, as well as the localities of Vălenii Șomcutei, Durușa, Mesteacăn, Fericea, Vărai). Satulung locality was not affected by the flood that occurred in May, during the Bârsău water overflow, because its riverbed was regulated and the hydraulic section has not been surpassed.

Comparing the value of the damages recorded in Bârsău basin with those in the middle sectors of Someș and Lăpuș basins, it is obvious that more than 50% of the damage (about 62%) occurred in the limits of latter. The slope`s runoff had an important share compared to river overflow of these two rivers (Fig. 7, right).

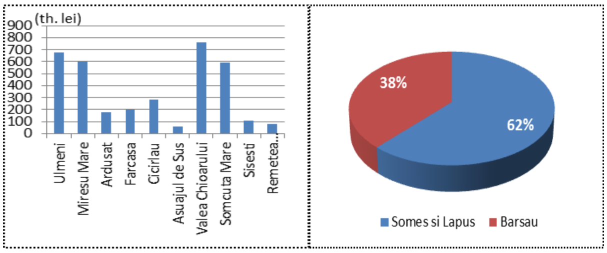

Fig. 7: Damages recorded within the Someș upper sector comparing to the neighbouring basins

The Among the villages affected by the Bârsău river, Valea Chioarului was the most affected (Fig. 5, left and right) and, close to this one, the Șomcuta Mare locality. Taking into account that Fericea river is part of Valea Chioarului commune, in the middle sector of Someș, but not Bârsău basin, it can be concluded that approximately 70% of the damages belong to the middle sectors of the Someș and Lăpuș catchment areas, and Șomcuta Mare is the most affected locality.

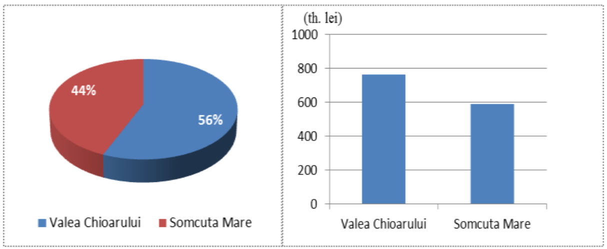

Fig. 8: Damages recorded in Valea Chioarului and Șomcuta Mare localities during the flood from May, 2015

In these two localities: houses, households, communal roads, streets, bridges, arable terrain, pastures and meadows, as well as fountains were affected. In the Valea Chioarului village, the maximum effects were reflected on some wooden bridges and over a concrete bridge while in Șomcuta Mare over the market, on two footbridges, on the locality water supply wells, on the sewerage network, and 67 animals died by drowning.

In Figure 9 the infrastructure damages recorded in those two localities are compared. Note that, excepting the households and communal roads, where the greatest damage was at Valea Chioarului, at the other indicators, Șomcuta Mare recorded bigger damages.

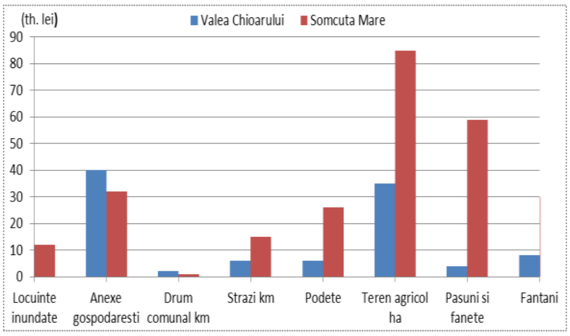

Fig. 9: Damage categories recorded during the flood from May, 2015

There were two wooden bridges destroyed, a concrete bridge was affected, the communal road has been gnawed and at Valea Chioarului side erosion took place. Creating flood prone areas related to water courses in Romania has been initiated by *Romanian Waters* National Administration, under 2007/60/EC Directive on the flood risk assessment and management - Hazard and flood risk maps. Capitalizing some information derived from this composite, an integrative map of the hydrological and associated risk related to flow with 1% probability in the Bârsău basin was created (Fig. 10).

Spatialized information allows the identification of some vulnerable areas located almost exclusively in the middle and lower sector of the Bârsău catchment area. Actually, every locality situated on the main course is exposed to high and medium risk. On the other hand, in the lower sector, low and insignificant risk is present.

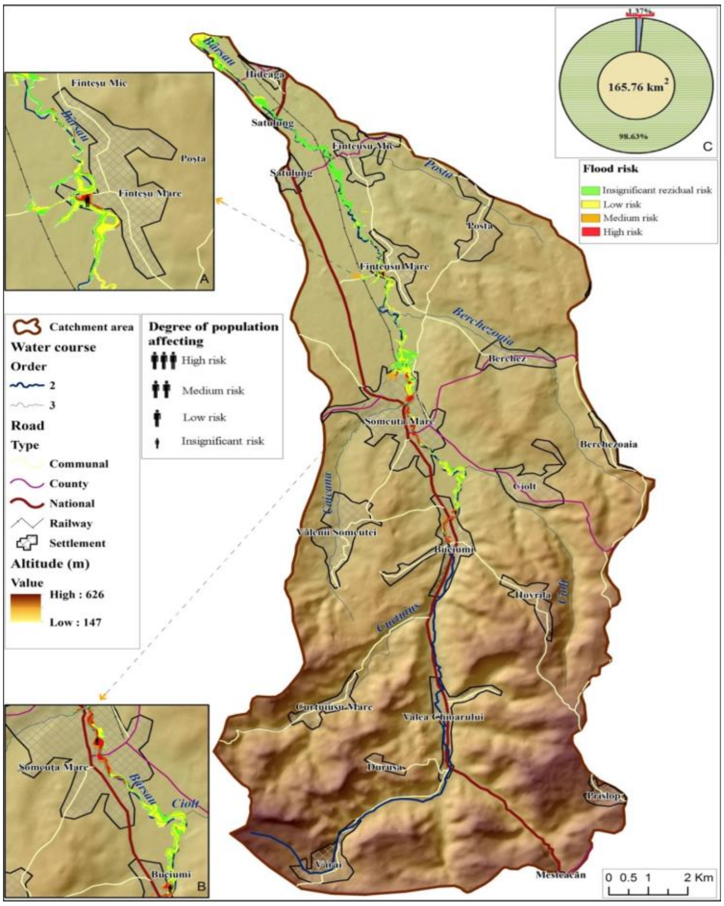

Fig. 10: Hydrological and associated risks related to maximum flow with 1% probability in Bârsău catchment area

Conclusions

The May 1970 flood was an exceptional flood, caused by rainfalls and also by the melting of snow, and floods that occurred in June 1974 and 2015 were pluvial floods, generated by heavy rainfalls during a short period of time. Șomcuta Mare is the most affected locality by the floods that occur in Bârsău catchment area, located in the junction area of Bârsău and its four tributaries: Curtuiuș, Căicana, Ciolt and Berchezoaia, torrential regime courses. Floods of the Bârsău river are usually accompanied by floods in neighboring small hydrological basins (Iadăra, Cicârlău and Sălaj), tributaries of the Someș river or on Lăpuș smaller tributaries.

The maximum reconstituted flow of Buciumi station is 80.6 m^3/s and it was achieved in June 2nd, 1974, and in May 2015, a maximum of 220 cm level was recorded (CP+20 cm), which corresponds to a maximum discharge of 60.3 m^3/s, the second historic flow value. After the flood that occurred in May 2015, the Bârsău riverbed was highly clogged, decreasing the transport capacity of the riverbed. Flooding is possible beneath the defense threshold levels because of the Bârsău river's overflow. It is necessary, on a length of about 8 km between Valea Chioarului and Satulung localities, to make desilting and recalibration works.

References

Barredo, J.I. (2009). Normalised flood losses in Europe: 1970–2006. *Nat. Hazards Earth Syst. Sci.*, *9*, 97–104

Corbuş, C. (2006). *CAVIS Programme*. INHGA, Bucureşti (in Romanian)

Gaume, E., Bain, Valerie, Bernardara, P., Newinger, O., Barbuc, M., Bateman, A., Blaškovicová, Lotta, Blöschl, G., Borga, M., Dumitrescu, Al., Daliakopoulos, I., Garcia, J., Irimescu, Anişoara, Kohnova, Silvia, Koutroulis, A., Marchi, L., Mătreaţă Simona, Medina, V., Preciso, E., Sempere-Torres, D., Stancalie, Gh., Szolgay, J., Tsanis, I., Velasco, D. & Viglione, A. (2009). A compilation of data on European flash floods. *Journal of Hydrology*, *367*, 70–78. doi:10.1016/j.jhydrol.2008.12.028

Horton, R.E. (1932), Drainage basin characteristics. Trans. Amer. *Geophys*. *Un.* 350-361

Lumbroso, D. & Gaume, E. (2012). Reducing the uncertainty in indirect estimates of extreme flash flood discharges. *Journal of Hydrology*, *414–415*, 16–30. doi:10.1016/j.jhydrol.2011.08.048.

Marchi, L., Borga, M., Preciso, E. & Gaume, E. (2010). Characterisation of selected extreme flash floods in Europe and implications for flood risk management. *Journal of Hydrology*, *394,* 118–133. doi: 10.1016/j.jhydrol.2010.07.017

Messner, F. & Meyer, V. (2006). Flood Damage, Vulnerability and Risk Perception – Challenges for Flood Damage Research. In: *Flood Risk Management: Hazards, Vulnerability and Mitigation Measures*, Series IV: *Earth and Environmental Sciences* – Vol. 67, Schanze J., Zeman E., Marsalek J. Edit., Springer, The Netherlands, 149 - 169.

Miller, V.C. (1953). *A quantitative geomorphic study of drainage basin characteristics in the Clinch Mountain area*. Virginia and Tennessee, Project NR 389042, Tech. Rept. 3, Columbia University, Department of Geology, ONR, Geography Branch, New York

Mustăţea, A. (2005). *Exceptional floods on Romanian territory - Genesis and effects.* Editura SC OnestaCom Prod 94 SRL, București (in Romanian)

Niţoaia, A., Şerban, Gh., Tudose, T., Nacu, S. & Rândașu-Beuran, S. (2016). The influence of atmospheric circulation, shape and pozition of the hydrographical basin on the amplitude and effects of the August 2005 flood in Ozana and Cracău basins. *Riscuri şi Catastrofe*, No. XV, *18* (1), 57-67

Posea, Gr., Moldovan C. & Posea A. (1980). *Maramureș County*. Editura Academiei Republicii Socialiste România, Bucureşti (in Romanian)

Rădoane, N., Rădoane, M., Olariu, P. & Dumitru, D., (2006). Small catchment areas, fundamental units of interpretation of the dynamics of landscape. *Analele Universităţii „Ştefan cel Mare" Suceava* (in Romanian)

Ruiz-Villanueva, V., Bodoque, J.M., Díez-Herrero, A., Eguibar, M.A. & Pardo-Igúzquiza, E. (2012). Reconstruction of a flash flood with large wood transport and its influence on hazard patterns in an ungauged mountain basin. *Hydrological Processes*, 27(24), 3424–3437. doi: 10.1002/hyp.9433

Schanze, J. (2006). Flood risk management – a basic framework. In: *Flood Risk Management: Hazards, Vulnerability and Mitigation Measures*, Series IV: Earth and Environmental Sciences – Vol. 67, Schanze J., Zeman E., Marsalek J., Editors, Springer, The Netherlands, 1-21

Schumm, S.A. (1956). The evolution of drainage systems and slopes in bad lands at Perth, Amboi, New Jersey. Geol. Soc. Ame. Bull. 67 (5), pp. 597-646.

Senzaconi F., Samaras I., Arghiuş V., Petrescu-Mag R. M., Costan, C. & Ozunu, A. (2010). *Critical Analysis of Flood Risk Management Strategies in the Context of Flood and Flash Flood Disaster Events in Romania*, IDRiM Conference, 1-4 September, Vienna

Sorocovschi, V. & Șerban, G. (2012). *Elements of Climatology and Hydrology. Second part: Hydrology*. Editura Casa Cărții de Știință, Cluj-Napoca (in Romanian).

Ujvari I. & Aniţan I. (1972). *Genesis, volume and runoff coefficients of the May 1970 catastrophic floods, on North-Western rivers of Romania*, Symposium „Causes and effects of the high waters from May-June, 1970", IMH, Bucureşti (in Romanian)

Vladimirescu, I. (1984). *Technical Hydrology bases*. Editura Tehnică, Bucureşti (in Romanian)

Ward, R. C. (1978). *Floods: A Geographical Perspective, Macmillan*, London, 244 pp

Zamfir, A. & Simulescu, D. (2011). Automatic delineation of a watershed using a DEM. Case study – The Oltet watershed. *Analele Universităţii „Ştefan cel Mare" Suceava*, Seria Geografie, *20*(1), 83-92. http://dx.doi.org/10.4316/GEOREVIEW.2011.20.1.25

Schanze, J., Zeman, E. & Marsalek, J., (eds.) (2006). *Flood Risk Management: Hazards, Vulnerability and Mitigation Measures*. Schanze, J., Zeman, E., Marsalek, J., Volume 67 of the series NATO Science Series, doi: 10.1007/978-1-4020-4598-1

*** (1970-1974). WMS Archives, Maramureș

*** (1992). Water Cadastre Atlas from Romania, Ministry of Environment, Forestry and Waters & Aquaproiect, Bucharest

*** (2015). Damages Synthesis Report– the flood from May 2015, WMS, Maramureş (in Romanian)

*** (2007). Directive 2007/60/EC on the assessment and management of flooding risk - Hazard and flood risk maps, The "Romanian Waters" National Administration http://gis2.rowater.ro:8989/flood