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EFFECTS PRODUCED BY THE FLASH-FLOOD FROM JUNE 1-2, 2019 IN THE DRAINAGE BASIN OF THE PIAN, RACHITA AND CIOARA RIVERS (MUREŞ DRAINAGE BASIN)

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ABSTRACT. The area affected by the floods that took place during 1st - 2nd of June 2019 is located in the southern part of Alba county, where significant precipitation had fallen in a very short time. The Pianu, Cioara si Rachita catchment areas are not monitored either from a hydrological or from a rainfall point of view. The rapid floods formed on the Pianu, Cioara and Răchita rivers with their cadastral and non-cadastral tributaries caused great damage in 4 municipalities (Pianu, Săsciori, Săliştea and Şibot): there were flows and extraordinary levels on Răchita and Cioara rivers. The largest damages were recorded in Pianu and Săsciori municipalities, whereas the lowest ones were enlisted at Şibot. The greatest destruction was made by Răchita river, that is 5 km long, followed by Pianu River. The flash floods affected households, institutions, county roads, street roads, forest roads, water and sewage networks, sewage plants, electricity and gas networks, telephony networks, cultural centres, shops, bridges, footbridges, pedestrian bridges, and agricultural crops. The total amount of the damages caused by flash floods on June 1st, 2019 was estimated at around 44.674,864 thousand lei, almost half of which were recorded in the radius of Pianu municipality. There were no human casualties, instead the flash-flood on Cioara river caught in and drowned 213 small animals. On Răchita river there was recorded a historical flash-flood, with a probability of occurrence of once every 200 years, whereas the historical flash-flood recorded on Cioara river (upstream the confluence with Freman river) had a probability of occurrence of once every 130 years; on Pianu river (at Pianu de Sus), the probability of occurrence was once every 35 years.

Keywords: torrential rain, flash-flood, dwelling, effects of the flash-flood

1. INTRODUCTION

Alba County is located in the mid-western part of the country [1], occupying an area of 6 241.57 km² that represents 2.6 % of the country's surface area, being the 16th county in Romania.

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The area affected by the floods of June 1-2 2019 is located in the south of Alba County and includes the municipalities of Pianu, Săliște, Săciori and Șibot (Fig. 1).

The slopes of the valleys are partly covered with broadleaf forests of various ages, logging being encountered on some areas.



Fig. 1. Geographical position of Alba County

Because of its geographical location, Alba county falls under the preponderant influence of the western movement of air masses [1], to which are added the influences of the polar or tropical air movement, depending upon the position and intensity of the main baric systems (cyclones and anticyclones — that generate and permanently influence these forms of air circulation in the lower layers atmosphere (cyclones and anticyclones — that generate and permanently influence these forms of air circulation in the lower layers atmosphere). Apuseni and Șureanu mountains in the west and south respectively constitute a climate barrier in the horizontal movement of air masses [7].

Pianu River (Mardile) -cadastral code IV-1.104, is tributary to the left of the Mureș River [2,3]. It springs from the Lung Hill (1 239.5 m) at an altitude of 1 225 m and flows into the Mureș river in the near of Vințu de Jos, at an altitude of 211 m. Pianu River has the following characteristics: length – 33 km, catchment area – 122 km², average elevation – 607 m, forest area – 5 205 ha [3]. Up, until upstream of the confluence with the Valea Tonii river, it has an average slope of 57 ‰; upstream of the confluence with the Ghenea it has an average slope of 56 ‰, the average slope throughout the entire river being 52 ‰ and the sinuosity coefficient – 1,09. As tributary streams, there are Valea Tonii river - right tributary, and Ghenea river – left tributary. The Valea Tonii river — cadastral code IV-1.104.1 [3], springs from Dealu Stroe (1 106.5 m) at an altitude of 1 000 m and flows into the Pianu river at an altitude

of 423 m in the near of Strungari village, is 8 km long, with 20 km² catchment area, the average elevation – 803 m, the forest area – 710 ha, the average slope throughout the entire river – 72 ‰ and the sinuosity coefficient – 1.24 [3]. The Ghenea creek – cadastral code IV-1.104.2 – is 9 km long, with 13 km² catchment area, an average elevation of 716 m (980 m on the spring and 382 m on the confluence), 852 ha forest area, an average slope of 66 ‰ and the sinuosity coefficient – 1,18.

The Pianu catchment area is adjacent to the east with the Sebeş river basin, with its tributary Răchita, and to the west with the Cioara (Valea lui Stan) river. (fig 2).

Cioara (Valea lui Stan) river, cadastral code IV-1.106, is a left-tributary of Mureş River, is 17 km long, with 48 km² catchment area, an average elevation of 434 m (700 m on the spring and 208 m on the confluence), 2 190 ha forest area, an average slope of 38 ‰ to the confluence with the Freman river and of 29 ‰, throughout the whole river, and with sinuosity coefficient of 1,14. It has a single cadastral tributary, Valea lui Freman, cadastral code IV-1.106.1, which has the following characteristics: length – 7 km, catchment area – 13 km², average elevation – 432 m (630 m on springs and 244 m on the confluence), forest area – 1 339 ha, average slope – 55 ‰, and the sinuosity coefficient – 1,16 [3].

Răchita river, cadastral code IV-1.102.14, is a left-tributary of Sebeş river and has the following characteristics: length – 5 km, catchment area – 10 km², average elevation – 452 m (550 m on springs and 290 m on the confluence), forest area – 464 ha, average slope – 52 ‰, sinuosity coefficient – 1,14. It flows into the Petreşti lake, laying on Sebeş River [3].

2. METHODOLOGY

Topographic maps of 1: 25 000 scale and licensed Arc GIS 10.6 of the two institutions (National Administration “Romanian Waters”, Bucharest and Mureş Water Basin Administration) were used to achieve the cartographic material.

The study of the out breaking conditions and of the characteristic elements of the flash flood were achieved on the basis of data and conclusions developed by the Mureş Water Basin Administration.

The analysis of the flash floods territorial impact was achieved on the basis of the data provided by the central and territorial specialised services of the Mureş Water Basin Administration, of those provided by the local officials, as well as on the basis of authors’ own findings during the field visits.

3. FLASH FLOODS

On 1.06.2019 the weather was unstable in the afternoon. CMR ‘Transilvania Sud’ Sibiu issued the yellow code weather warning no. 37 for the southern area of the Alba county, valid for the 1 June (h. 10.00) – 2 June (h. 06.00) interval. As a result of the evolution of atmospheric instability, CMR ‘Transilvania Sud’ Sibiu issued the orange

code alert of dangerous weather conditions No 217 – valid between H. 18.40 and H. 19.30 for the following municipalities: Cugir, Blandiana, Ceru Băcăinți, Pianu, Săliște, Săsciori and Șibot. It appears that the cloudy system was stationary in the area and there were recorded heavy rains accompanied by electrical discharges.

CMR ‘Transilvania Sud’ Sibiu issued the yellow code warning of dangerous weather conditions No 218 – valid between H. 19.45 and H. 21.00 for the municipalities of Sebeș, Călnic, Cut, Doșat, Săsciori and Șpiring.

The highest rainfalls measured between 1 June (h. 6.00) and 2 June (h. 6.00) were recorded to the Petrești storage on the Sebeș River – 42.8 l/m². At Cugir hydrological observing station on river Cugir, there were recorded 23,7 l/m². The following quantities of precipitation were also recorded on the Sebeș river: 31.6 l/m² at Nedeiu storage, 20.0 l/m² at Sebeș hydrological observing station and 17.8 l/m² at Tău Bistra storage [4]. It is noted that the largest amounts of precipitation fell in the south area of the county, in the area of the municipalities of Săliște, Pianu and Săsciori (Răchita and Sebeșel villages), where the nucleus of the rain was concentrated, but which is not monitored from a rainfall point of view.

The particularly significant amounts of rain that have fallen, as well as the entrainment of the run-offs from the slopes and the reactivation of some torrents, have led to an increase of the flow rates of small cadastral water streams: Răchita, Pianu (with its tributaries Valea Tonii and Ghenea) and Cioara, with its tributary Freman.

Apparently, the flash flood on Pianu river did not overlap with the flash floods on Valea Tonii and Ghenea rivers and thus the warning level was not exceeded at Vințu de Jos. On the contrary, it appears that the flash flood on Cioara River overlapped with that on the Freman river.



Fig. 2. Flood Restoration Area

Following the reconstitution in the field of the flowing through recorded on Pianu, Cioara and Freeman rivers at June 1 2019, the following values were obtained:

Răchita river 106 m³/s, Pianu river (at Pianu de Sus) 114 m³/s, Pianu river (at Vințu de Jos) 73.5 m³/s, Freman river (upstream the confluence with Cioara river) 85 m³/s, Cioara river (upstream the confluence with Freman river) 73 m³/s, Cioara river (downstream the confluence with Freman river) 158 m³/s [4].

Table 1 covers the measurement sections, the maximum flowing through resulting from the reconstitution in the field, and the probability of occurrence for the respective flow rates by comparison with the flow rate of 1 %.

Table 1. Hydrological data at gauging stations

Ref. no	River	Measurement section	Maximum flowing through	Q _{1%} m ³ /s	Probability of occurrence
1	Freman	Upstream the confluence with Cioara river	85mc/s	57,7	Every 140 years
2	Cioara	Upstream the confluence with Freman river	73 mc/s	86	Every 80 years
3	Cioara	Downstream the confluence with Freman river	158 mc/s	126	Every 130 years
4	Răchita	1 km upstream upstream of the confluence	106 mc/s	51,5	Every 200 years
5	Pianu	Vințu de Jos hydrological station	73,5 mc/s	230	Every 30 years
6	Pianu	Pianu de Sus	114 mc/s	170	Every 35 years

The peak discharge of flash flow at the Vințu de Jos hydrological observing station was 73.5 m³/s, about 97 times higher than the multiannual average flow rate during the month of June (i.e. 0.758 m³/s). The monthly average flow rate for June 2019 was 1,88 m³/s, influenced by the values of the flash flood of June 1-2, 2019.

4. EFFECTS OF FLASH FLOODS ON THE NATURAL AND AN-MADE ENVIRONMENT

There were no human casualties, but the flash flood on the Cioara river caught in 213 animals (140 goats, 25 piglets and 50 hens) which drowned, in the village of Balomiru de Câmp (municipality of Șibot) [4]. Table no 2 lists the damages recorded during the flash floods of June 1, 2019 [4,5].

Table 2. Damages recorded during the flash floods of June 1, 2019

Ref. no	Affected municipality	Objectives affected		Causes of damages
		Physical	Value – in thousands of lei	
1	Municipality of Pianu Pianu de Jos village Pianu de Sus village	Households 239	644,5	Heavy rain Leakages from the slopes Flow rates fluctuations
		County road 6,2 km	6967,42	
		Bridges 3	6413,76	
		Communal road, streets 4,2 km	3700	
		Pedestrian bridges 5	200	

	Strungari village	Culverts 7	100	Flash floods on Valea Măcui, Valea Cornii and Valea Leii torrents
		Forest roads 6,5 km	2200	
		Telephone network – 1 km	18,56	
		Agricultural crops 8,69 ha	65,732	
		Water supply and sewerage networks 0,26 km	94,136	
		Electric grid – 0.2 km	10	
		Affected hydraulic works	1762,958	
2	Municipality of Săciori Răchita village Sebeșel village	Households 147	1372,75	Heavy rain Leakages from the slopes Flow rates fluctuations Flash floods on the Răchita creek and on the Valea Beilului torrent
		County road 4 km	14398,81	
		Bridges 3	4085,65	
		Concrete retaining wall 0,03 km	22,56	
		Community center 1	8,03	
		Wasted water treatment plant 1	68,25	
		Sewerage network 0,6 km	6,14	
		Streets 0,945 km	54	
		Water course erosion and silting-up 3,35 km	238	
		Electric grids – 2.5 km	262	
		Telephone network – 2 km	47,82	
		Water supply and sewerage networks 0,17 km	114	
		Gas grid 0,015 km	58,254	
		Agricultural crops 6,6 ha	28,728	
3	Municipality of Sălișteea Sălișteea village	Households 79	543,33	Heavy rain Leakages from the slopes Flow rates fluctuations Rapid flash floods on Cioara river, on Freman river and on torrents (Oarbei creek, Socului creek, Sentea creek)
		Local administration goods 6	22,21	
		Culverts 5	7,18	
		Streets 0,95 km	572,6	
		Forest road 5,15 km	182,5	
		Farm road – 0,022 km	1,1	
		Forest bridges 3	60	
		Communal road bridge 1	1,92	
		Football field 1	56,22	
		Water supply and sewerage networks 0,1 km	30	
		Gas grid 0,02 km	23,114	
		Agricultural crops 0,53 ha	2,432	
		4	Municipality of Șibot Balomiru de Câmp village	
Of which: goats 140, piglets 23, hens 50				

5. AFFECTED HYDRAULIC WORKS AND RIVERBEDS

Pianu River (Mardile), is developed on two sectors: first sector lays in the near of Strungari village, whereas the second sector is located downstream of Strungari village. In the village of Strungari there is a riverbed regularization of 700 metres

length whereas, downstream, Pianu river is regulated on both sides, with a 17970 meters length of the regularised bed [7,8].

Răchita river is not developed from a hydrotechnical point of view, but there are some sectors with concrete retaining wall that protects the local road or the county road.

Neither Cioara river nor its tributary Freman are hydrotechnical developed.

Răchita river caused erosion and silting of the riverbed over a length of 3.35 km, and a concrete retaining wall in Sebeșel village was affected over a length of 0.03 km, with an estimated value of the damages to the hydrotechnical constructions of 1762.958 thousand lei. In the radius of Sălișteța municipality, Cioara and Freman rivers produced important water course erosions and siltings over a length of 3.7 km [5].

In the radius of Pianu village, the leakages from the slopes, torrents and the important water discharges which flowed in a very short time have silted the riverbed of Pianu river over a 10 km length. 9 bottom sills were destroyed whereas 5 bottom sill were clogged. There were two sectors on the river Pianu where the riverbed silted – first, between the villages of Strungari and Pianu de Sus (Fig.3), and the second between Pianu de Sus and Pianu village, where a pitch caused a riverbed change, the river forming a new one (PM5).

The riverbed unsilt and recalibrating works developed downstream of Strugari village are shown in Figure 4.



Fig. 3. Riverbed and communal road erosion – downstream of Strungari village – photo C.A. SAFTA

The water-course regulation works were affected as follows: 0.19 km gabion wall bank protection, 0.018 km embankment shore protection, 1.3 km flood defence works. The thalweg of Pianu river riverbed deepened over a length of 1.4 km and the banks were eroded over a 0.55 km length [4,5].

Following the events of June 1, 2019, the SGA Alba amended the 2019 Technical Plan and mobilised in disaster areas all the fitted hydro-ameliorative machinery and

lorries. The works were carry out with 2 backhoe loaders, 3 excavators, 1 bulldozer and 3 lorries.



Fig. 4 Pianu riverbed recalibration – downstream of Strungari village – photo C.A. SAFTA



Fig. 5 Silting and riverbed change – downstream of Pianu de Sus – photo C.A. SAFTA



Fig. 6. Riverbed unsilt and restoring the old riverbed of Pianu river – photo C.A. SAFTA

The situation of works carried out under the Technical Plan is shown in Table 3.

Table 3. Status of the works carried out as a matter of urgency by the SGA Alba

Number	Works Denomination	Works carried out under Technical Plan 2019	
		Physical	Value (thousands of lei)
1	Răchita river development	Water course sanitation – 5 km Re-profiling, riverbed unsilting – 5 km/14600 m ³	70,7
2	Pianu river and tributaries development	3 km water course Re-profiling, riverbed unsilting – 3 km/11500 m ³	35,6
3	Cioara and Freman rivers development	2 km water course Re-profiling, riverbed unsilting – 2 km/3500 m ³	15,8

6. EVENTS IN THE STUDY AREA

The south area of Alba County comprises the municipalities of Cugir, Pianu, Săliște, Săsciori, Șibot and Șugag. There were counted the events occurred during the 2006-2019 period and it results that the most affected area was the Pianu municipality – 12 events, followed by the town of Cugir – 11 events and the municipality of Șugag – 10 events.(figure 4). The least affected were the municipalities of Săsciori – 6 events and Săliște – 5 events [6].

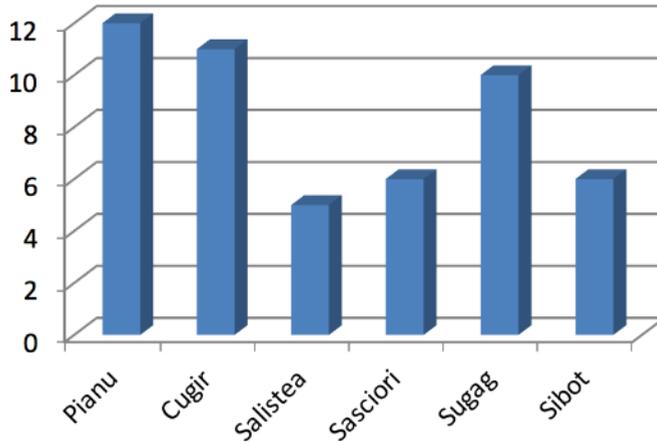


Fig. 8. Number of events for the 2006-2019 period

For the 2014-2019 period, there were 5 events in the radius of the Pianu municipality, of which the June 1, 2019 and June 10, 2018 events produced the greatest damages. In both events, Valea Leii river caused significant damages (figure 5).

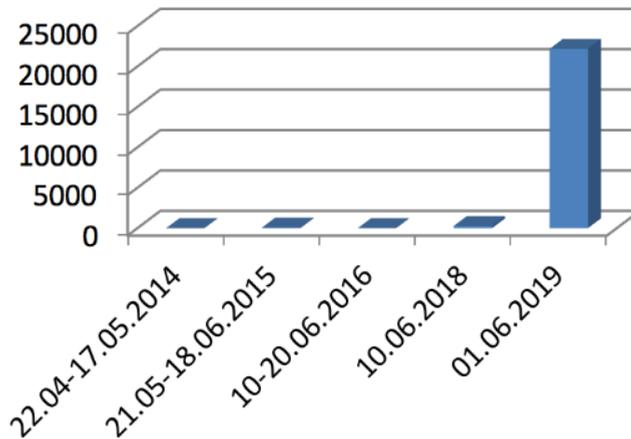


Fig. 9. Pianu events 2014-2019

The events produced in 2014, 2015 and 2016 did not record large damages. The June 1, 2019 event was the greatest, both in terms of flash floods and resulting damages.

Pianu, Săliște, Săciori and Șibot municipalities have been affected, the total value of the damages being RON 44674.864 thousand lei, with Pianu and Săciori municipalities being the most affected (Figure 6). The municipality of Șugag was not affected by the event [6].

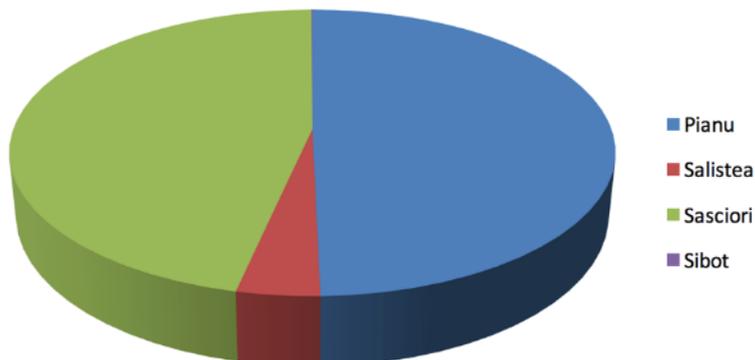


Fig. 10. Damages caused to municipalities 1.06.2019

CONCLUSIONS

Municipalities of Pianu (with Pianu de Sus, Pianu de Jos, Strugari villages) and Săciori (with Răchita and Sebeșel villages) were the most affected by the June 1, 2019 event, with a total damages of RON 44674.864 thousand lei.

Flash floods on Pianu, Răchita, Cioara, Freman and Valea Leii rivers are frequent frequent phenomena, being produced by heavy rainfall, often torrential. Undeveloped rivers, the unsanitized torrents' streambeds and valleys, plant debris withdrawn after logging – all these lead to widespread flash floods and riverbed pitches, to the first obstacles bridge-type or narrowings.

Flash floods of June 1, 2019 were exceptional events for Răchita, Freman, Cioara and Valea Leii rivers.

The municipalities of Pianu, Cugir and Șugag were the most affected by the floods in the 2006-2019 period. The Șugag municipality was not affected by the June 1, 2019 event.

The municipalities of Săliște, Pianu (with Pianu de Sus, Pianu de Jos, Strugari villages) and Săciori (with Răchita and Sebeșel villages) are located along Cioara, Pianu and Răchita rivers, and there is permanent risk of flooding in case of a heavy rain event.

Since many of the damages produced in the radius of Strungari village were produced by Valea Leii river (unregistered from a cadastral point of view), the municipality of Pianu needs to take steps to obtain funds to regularise this water course.

Forest District of Pianu will have to manage the torrents in its area of activity.

There were no human casualties, but the flood on Cioara river caught in and drowned 213 animals (140 goats, 23 piglets and 50 hens).

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