DAMAGES ASSESSMENT ASSOCIATED TO THE FLOOD EVENT WHICH OCCURRED ON 11-14 JULY 1999 IN THE RÂUL MARE BASIN

VĂIDEAN ROXANA[1], HOGNOGI GH. [1]

ABSTRACT. **Damages assessment associated to the flood event which occurred on 11-14 July 1999 in the Râul Mare basin.** One of the most destructive phenomena among natural disasters that manifest in the mountainous regions are flash floods. In Retezat Mts. area these phenomena have caused major damages to private and public properties, environmental problems and even human losses. On the 11-14 July 1999 there was an extreme event caused by huge amount of rainfalls which have locally exceeded 240 mm in 20 hours. The meteorological and hydrological conditions corroborated to catchments characteristics had determined flash floods occurrences on the streams and torrents of Retezat slopes. Moreover, hydrological phenomena have triggered other processes like debris floods and debris flows causing 13 casualties and enormous economical damages, as the hydro-energetic Raul Mare-Retezat system and Gura Apelor dam was also affected. The assessment of the flash floods effects offers a general view of the magnitude of these events and emphasizes the necessity in developing mitigation plans and countermeasures in order to minimized future consequences.

Keywords: flash floods, effects, damages, human losses, Râul Mare, Retezat Mts.

1. INTRODUCTION

Flash floods are among the most unpredictable phenomena that manifest themselves in the channel of the mountain streams. They are usually triggered by local meteorological conditions which generate high intensity rainfalls (Norbiato et al. 2008, Arghiuş et al., 2010, Goron et al., 2012). In addition to this, the morphometrical parameters and lithological conditions of the area have an important role in flash floods manifestation, as they usually occur in small catchments characterised by steep slopes (Marchi et al., 2010).

In Romania, during the last period, there were encountered both human and material losses due to floods and flash floods occurrences. Between years 1991-2000 fluvial processes have caused 235 casualties and 80% of the damages associated to natural hazards were produced by them (Arghiuş et al., 2007).

In Retezat Mountains area there have been registered some major flood events which caused not only a lot of damage to infrastructure and private properties but also fatalities (13 deaths registered in the last major event) and environmental problems (Bălteanu et al., 2004).

[1] "Babeş-Bolyai" University, Faculty of Geography, 400006 Cluj Napoca, Romania
E-mail: augusta.vaidean@ubbonline.ubbcluj.ro; gheorghehognogi@yahoo.com

The study site is represented by the upper and middle basin of Râul Mare, formed at the contact of four different morphological units (Fig.1). The main collector is the most important tributary of Strei River, draining an area of 380 km² which extends from an elevation of 2509 m a.s.l. to 480 m a.s.l., the average altitude being of 1581 m. The Gura Apelor reservoir is part of the Râul Mare – Retezat hydropower system located at the confluence of the Lăpușnicul Mare, Lăpușnicul Mic and Șes rivers. The reservoir has a complex role, the main purpose being electricity provision but also it is used as water supply for consumers and civil protection against floods. The dam of the lake placed between 910 m – 1078.9 m a.s.l, is a rock fill dam and has a height of 168 m, being among the highest dams built of local materials in Europe. Also, the lake has a surface of 380 ha and a bulk volume of 210 mil.m^3.

Given the high altitude of the study area corroborated with lithological particularities and other morphometrical parameters, the hydro-meteorological phenomena frequently trigger other slope processes like debris-flows or landslides which enhance the power of destruction and cause even more damages. Depending on the magnitude of the event there can be registered human losses, severe injuries, deterioration of the health condition or perturbations of human activity.

The main purpose of this study is to assess the damages associated to the flood event which occurred on 11th-14th of July 1999, in the upper and middle basin of Râul Mare. The assessment of the flash floods effects offers a general view of the magnitude of these kind of events and emphasizes the necessity in developing mitigation plans and countermeasures in order to minimized future consequences.

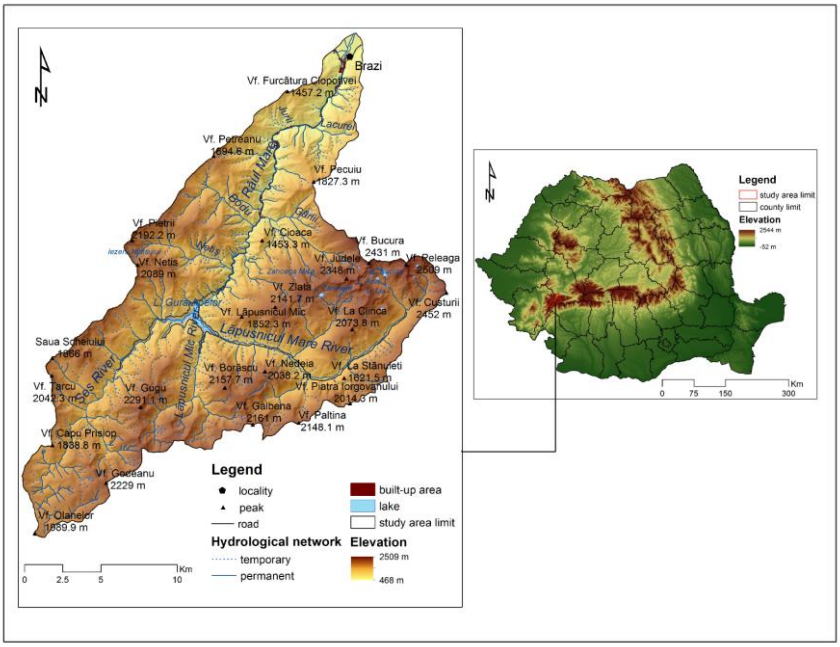

Fig. 1. ***Geographical position of the study area***

2. METHODOLOGY

The assessment of the flood consequences is primarily focused on the direct damages generated especially to the private and public constructions and loss of human lives. Secondly, we tried to asses other negative consequences reflected on human society and on the environment.

For the assessment of the event magnitude we collected data and information regarding the rainfall event which triggered the flash floods provided by SC Hidroelectrica SA (own hydro-meteorological network). The immediate effects of the massive amounts of rainfall were highlighted by the water level rising in the river and in the lake, based on data received from the same institution mentioned above. Also, the solid transport data for the studied event was offered by ABA Mureș.

In the field we gathered all the relevant information related to the event. The computation of economical damages and costs were based on the remedial works carried out by SC Hidroelectrica SA to eliminate the effects of the floods. We indentified the most important changes which still could be observed (morphological changes particularly) in the field. Another necessary method applied in order to obtain population's perception regarding the flood event was the interview. The accounts of the eyewitnesses (including victims) who had clear recollection of the event subsequently helped us to estimate the level of stress.

The processing of data and of the results were accomplished and graphically illustrated using specialized softwares (GIS, MS Excel).

3. METEOROLOGICAL CONTEXT AND HYDROLOGICAL RESPONSE

During the interval between 11 and 14 July 1999, there was an extreme event which affected the entire area of Retezat Mts. After 4 days of rain which totalised a quantity of 66.5 mm (Fig. 2), on the night between 11 and 12 of July, there was registered a rainfall of high intensity which locally exceeded 135 mm in 7 hours. The heavy rains had continued to fall even in the following days, the total amount of precipitation registered at Gura Apelor station on the 11th-14th interval being of 241.2 mm (Fig.3). Under this circumstances, all catchments located upstream or downstream the Gura Apelor reservoir, were affected by flash floods and other mass transfer processes.

Given the high amount of debris available in the upper part of the catchments, in some narrow sectors of the streambed, log-jams and natural dams were created. On a torrent situated downstream the dam of Gura Apelor reservoir, because of the outbreak of the temporary dams and the high amount of solid materials transported, the flash flood turned into a debris flow which rushed into Tomeasa colony destroying the buildings. There were massif suspended load discharges on all torrents, the value measured at Gura Apei station (Lăpușnicul Mare River) showing a maximum of 183 kg/s which exceeds more than 200 times

the mean annual value of 0.817 kg/s. As a consequence, the contribution of the phenomena to the Gura Apelor reservoir silting process was really significant, the total volume of the sediments being estimated at ≈120 000 m³.

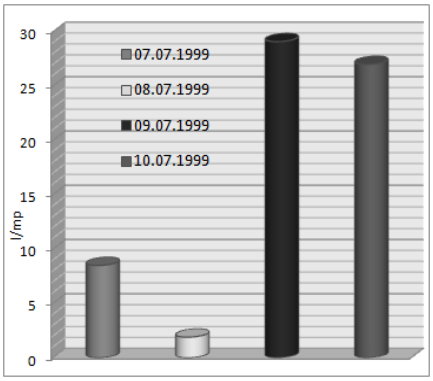

Fig. 2. ***Antecedent rainfall amount registered at Gura Apei station***

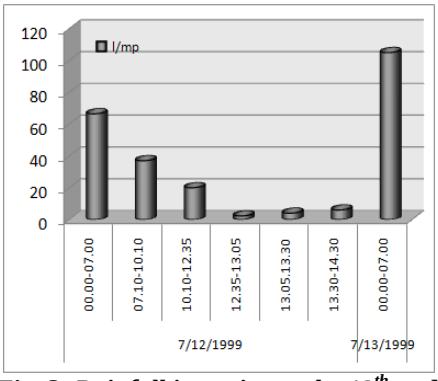

Fig. 3. ***Rainfall intensity on the 12th and 13th of July 1999 at Gura Apei station***

The maximum flow discharge registered at Gura Apei hydrometric station (Lăpușnicul Mare River) in the 11-14.07.1999 interval was of 194 m³/s, a value which contrasts with the annual mean of only 4,75 m³/s (Table 1). The maximum water depth during the peak flow was registered on the 12th with a value of 6.65 m, three times deeper than the annual mean (2,23 m). On Râul Mare the reconstructed values of the flow discharges revealed a maximum of 1345 m³/s. According to engineer Dan Florescu, this reconstructed value corresponds to a probability of 1/1000 years, which is the design limit for AHE Râul Mare-Retezat.

Table 1. ***The values of the flood parameters registered at the Gura Apei hydrometric station on Lăpușnicul Mare River in contrast with the mean and extreme values.***

Day	H (m)	Q (m³/s)	R (kg/s)
11	2.89	23.9	11.3
12	4.76	194	183
13	2.92	20.3	10.4
14	2.97	21.7	12
Annual mean	2.23	4.75	0.817
Annual max.	6.65/12,VII	412/12, VII	390/12.VII
Annual min.	1.97/19, X	1,34/5, II	0.0

At the beginning of the event at 2 a.m. (12.07.1999) the water level of the Gura Apelor reservoir was at 989.62 a.s.l. The maximum level was registered at 8 p.m. on 13th at 1011.9 a.s.l, from which results a total increase of the water level in the reservoir of 42 hours (Fig.4).

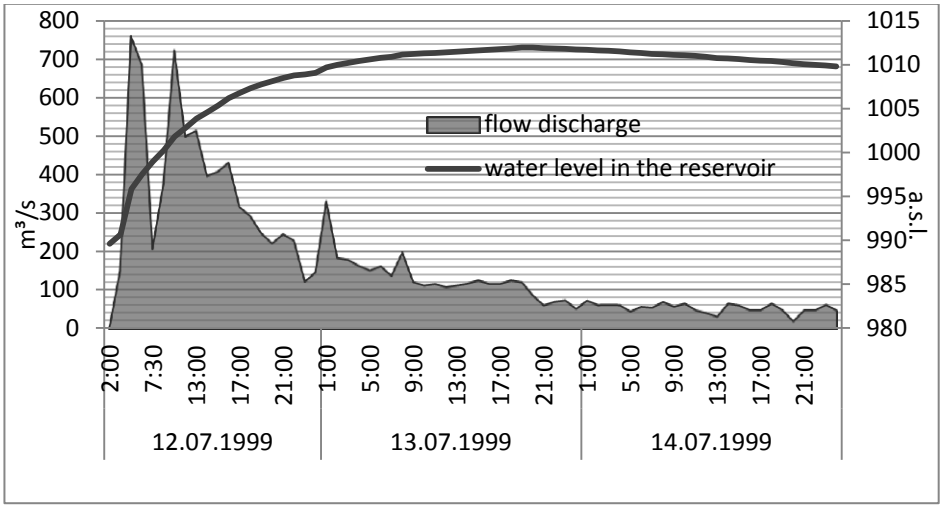

Fig. 4. ***The evolution of the discharge values (based on tributaries discharge) and of the water levels in the reservoir during 12-14.07.1999 interval.***

4. RESULTS

4.1. Economic damages

In the studied area, one of the most vulnerable elements to flood and associating phenomena is the Râul Mare-Retezat hydropower system and the corresponding infrastructure. After the event, damages were encountered both to road infrastructure and to the system's utilities.

Thousands of m³ of rock and wood debris blocked the access to the Tomeasa colony, making the river to overflow on the main road. All the roads downstream the Gura Apelor dam, were blocked and in some sections they were completely destroyed (Fig. 6.). The reservoirs situated downstream the Gura Apelor dam, were affected especially by silting. The most affected was Ostrovul Mic which based on the measurements performed on October 1999 and the ones achieves after draining the lake on September 2000, the total volume of the sediments were estimated at 200 000 m³ (Fig. 7). Also, the silting processes had affected the cooling circuits of the generators filters and as a consequence the turbine of the Retezat Hydropower Station was no longer functional for a period of time. The cost for repairing the damages to the Râul Mare - Retezat hydrological system was about 3 000 000 RON (Fig. 5).

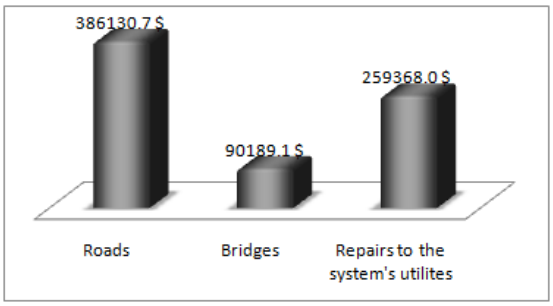

Fig. 5. ***The value of the damages associated to the event, supported by SC Hidroelectrica SA***

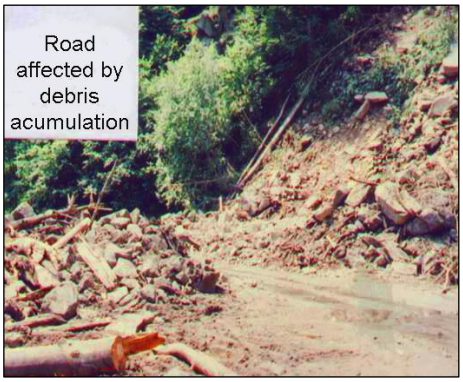

Fig. 6. ***Debris accumulated on the acces road to Gura Apelor dam (July, 1999)***

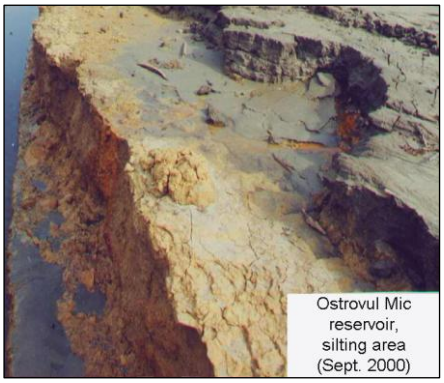

Fig. 7. ***Silting process at the end of Ostrovul Mic reservoir (September, 2000)***

4.2. Social impacts

Although floods are common hazards, which frequently occur in our country, the mortality related to these events is relative low. But under some circumstances, the high unpredictability of these phenomena is responsible not only for material damages but also for human losses.

The Tomeasa settlement was formed by several buildings where the employees of the Râul Mare-Retezat Hydrological Power were living together with their families. On the night between July 11 and 12 they were surprised in a building which was destroyed by tones of rocks, trees and other debris transported by the process. This unfortunate incidence caused 13 deaths among 4 children, 21 injured and 30 homeless. In order to prevent the spread of diseases among population, the Public Health of Hunedoara County launched a vaccination campaign. The employees of the Retezat National Park were also surprised by the event and they were isolated for 2 days until the authorities could reach them. The inhabitants of the localities which were situated at the contact of the mountains to the Haţegului Depression were also affected. Some of the houses had to be evacuated as they were no safe anymore for the inhabitants. As most of the private properties affected directly by the flood were not insured many people who lost all their assets and belongings became homeless. Besides the loss of houses and other goods, many people had lost all their livestock and crops which for many were essential for daily living. Phsyco-social effects on flood victims accentuated by the loss of the loved ones can traumatize them for a long period of time. Also, removal from one's home, property or livelihood loss or activity interruption may cause stress or have other psychological impacts.

4.3. Ecological effects

The ecological effects of this area are also important as it is part of Retezat National Park which includes the Gemenele - Scientific Reservation. The high

energy of the water in streams had lead to a strong erosion of the streambed and banks which caused the occurrence of other processes. Consequently, there were negative effects on the ecosystem especially on vegetation and fauna.

The fresh waters of streams and rivers represent an adequate habitat which sustains the fish and other aquatic species existence. This is a fragile environment and any change in water quality can determine population decline. The most sensitive is the trout which populates the fresh streams in the upper part of the basin. After the flood, the water in reservoirs had a yellowish-brown color and a viscous texture for about a month which certainly enhanced the fish mortality.

To these we add the destruction of the forest which grows on the alluvial fans or along the channels. The impact of the trees with the debris transported by the flash flood or other processes caused them many disturbances (uprooting, decapitation etc.). In some cases, almost the entire forest populating the fans was destroyed. The logs and timbers accumulated in the narrow sectors of the streambed formed temporary log dams. As a consequence, the surface area affected by the flow on both sides of the main channel, increased and moreover the breakage of these dams enhances the power of destruction of the floods downstream.

5. DISCUSSION

The concomitance of a period of successive rain events which bring up the sediments to saturation followed by an intense rainfall, create favourable condition for flash floods triggering. Moreover, other particularities such as lithological conditions and morphometrical features of the basin influence the manifestation parameters of the flash floods and of the associated phenomena. As a consequence, there can be registered high discharge values both liquid and bed-load or suspended load discharges. The reconstructed flow discharge values obtained for the event which occurred on 11th to 14th of July 1999, revealed a maximum of 1345 m^3/s which corresponds to a probability of 1/1000 years. In the absence of the Gura Apelor reservoir, all the localities and other anthropic objectives situated on Clopotiva - Mureș sector would have been severely affected. For an efficient and long term use of the Gura Apelor reservoir, the transit of the sediment which influences the silting rates needs to be carefully monitored as this process leads to reduction of the storage volume.

The high number of people killed in just one event emphasizes the unpredictability of the flash floods events and related phenomena as a consequence of the fast response of the drainage systems to heavy rainfall. The efficiency of a prompt and accurate weather forecasting is based on homogeneous distributed meteorological network. In our country the meteorological network is not very well developed and in some cases the extreme meteorological events which usually affect small areas are even more difficult to forecast.

The most affected anthropic objective was Râul Mare-Retezat hydropower system. The accumulated amount of the damages had risen to 3mil. RON and the

costs and works continue even today. After 2000, the high potential of tourist attraction of the area determine people to invest in developing a vast accommodation network, which is exclusively placed on the Râul Mare floodplain. Though Gura Apelor reservoir has proven its valuable contribution to flood control, one should not neglect the destructive power of the flash floods which can occur on the catchments located downstream. In order to prevent or diminish future effects of the floods and associated phenomena it is extremely important to take some early measures.

6. CONCLUSION

Between 11 and 14 July 1999 the upper and middle basin of Râul Mare was affected by an extreme event which caused 13 casualties, 21 injured and 30 homeless. The high amount of rainfall corroborated with the antecedent precipitation which already saturated the soil had caused the occurrence of flash floods. The maximum flow discharge value on the Râul Mare River in the absence of the Gura Apelor reservoir was calculated at 1345 m^3/s which corresponds to a probability of 1/1000 years.

The effects of the disaster were manifested at the level of all geo-components of the system (social, economic and environmental). Besides the human losses there were 3mil.RON economic damages and other ecological negative consequences which proved to be difficult to quantify.

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