THE HYDROLOGICAL RISK IN THE MOLDOVITA RIVER BASIN AND THE NECESSARY MEASURES FOR THE ATTENUATION OF HIGH FLOOD WAVES

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ABSTRACT. – The Moldoviţa river basin is situated in the northern part of Eastern Carpathians. It is a main right side tributary of Moldova river. The average multi-annual flow recorded in Lunguleţ and Dragoşa hydrometric stations has the value of 1.638 m^3/s, and 5.099 m^3/s, respectively. The last catastrophic floods in Moldovita river basin occurred on 26th July 2008, with the high flood wave at 17:00. A maximum flow of 539 m^3/s was recorded and a water level rise to 400m. The high flood was devastating, damaging many houses and household attachments, social and economic buildings. Over 20 ha of agricultural land were affected in Vatra Moldoviţei. The waters flooded over 7 households in Valea Stânei village and in Ciumârna, four gabions on the left river bank and 2 little bridges were destroyed. In Vatra Moldoviţei village, 180 m of dam as well as a footbridge were destroyed, and a wood deposit was flooded. In Paltinu village, the commune road was 70% damaged, two bridges were severely affected, and the bridge defence collapsed over a distance of 50 m. As a result of the anthropical intervention, the catastrophic floods are more and more frequent.

Key words: floods, hydro technical works, deforestation, management.

1. INTRODUCTION

The aggressiveness and frequency of the torrential rains, especially of those exceeding 100 mm in 24 hours cause increased flows in most of the Romanian rivers. In the last 10 years the floods in eastern Romania have had an almost regular frequency of 2 years. In this time interval, the Siret, Suceava, Trotuş, Prut rivers etc. recorded historical flows (Romanescu, Nistor, 2010; Romanescu et al., 2011).

Moldoviţa river basin, in the northern part of Eastern Carpathians, is affected greatly by massive deforestation and tree fell. For this reason floods are very frequent, with significant material and even human losses. As this region is a very important tourist area, it is imperative that the damages are diminished and the necessary measures are taken immediately.

Although floods became repeated and usual phenomena in the eastern part of Romania, detailed studies have been done sporadically, and most of the time they did not have a practical finality. The most important contributions to the study of floods in the east of Romania or to the research of the general principles causing

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their recording belong to the following authors: Apostol, 1985; Diaconu, 1999; Mustăţea, 2005; Podani, Zăvoianu, 1992; Romanescu, 2003, 2006, 2009; Romanescu et al., 2009, 2011; Smith, Ward, 1998; Sorocovschi, 2003, 2007, etc.

2. GEOGRAPHICAL LOCATION

Moldoviţa river basin is situated in the north of Romania, in the northern part of Eastern Carpathians, in Obcinele Bucovinei Mountains. The river has its source at the altitude of 1200 m, a length of 51.6 km and the area of the river basin covers 563 km^2. After draining the mountain territory, the river flows into the Moldova River, a tributary of the Siret River (Fig. 1).

The river basin stretches on NW-SE direction and its shape is symmetrical. Moldoviţa river basin gets narrower next to Vama, at the confluence with Moldova River. The mathematical limits are: $47^{0}30'$ and $47^{0}50'$ north latitude and $25^{0}36'$ and $25^{0}46'$ eastern longitude.

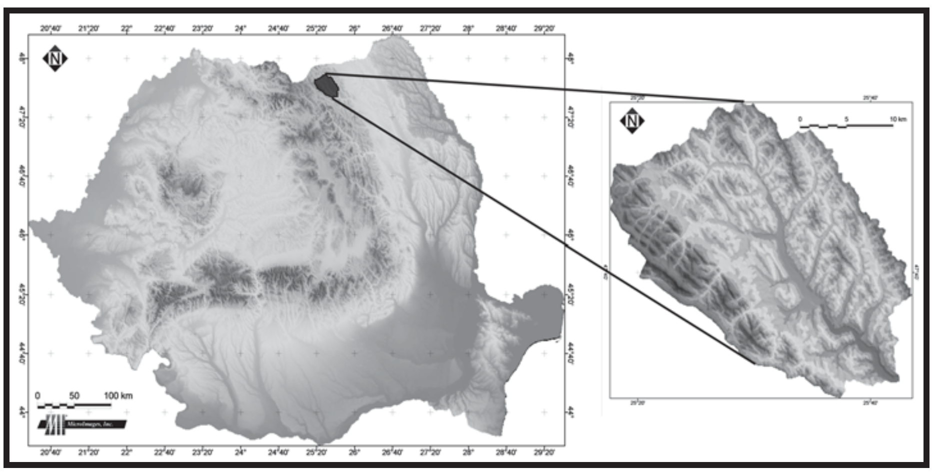

Fig. 1. ***Geographical location of Moldoviţa River on the territory of Romania***

3. METHODOLOGY

The statistical data were obtained from Siret Basin Administration in Bacău, Moldova Meteorological Centre in Iaşi and Romanian Waters National Administration in Bucharest. The data were processed within the Geo-archaeology Laboratory, Faculty of Geography and Geology, Iaşi.

Field observations and measurements were done in 2006, 2007, 2008, 2009 and 2010, along the flood plain of Moldoviţa River. Daily water levels were monitored in the three stations and topographical measurements were done upstream and downstream these stations.

All the analysed data were collected from 2 Hydrological Stations (Dragoşa and Lunguleţ) and they refer to the maximum flows recorded in the period 2006-2010.

4. RESULTS AND DISCUSSIONS

The factors generating the floods are connected to the landforms (morphology, slope, and cross section), climate (precipitations and temperatures), vegetation, human activity etc.

Moldoviţa Valley reflects the typical features of the valleys developed in mountain regions. The alternation of narrow valley sectors with wider sectors, the asymmetry of the transversal profile, the altitude differences, the variation of the slopes etc give a clear personality to this landform unit.

In Lunguleţ and Dragoşa hydrometric stations the multi-annual average flows are 1.638 m^3/s and 5.099 m^3/s, respectively. In Dragoşa hydrometric station the highest flows were recorded in 1950, 1969, 1970, 1072, 1973, 1978, 1979, 1981, 1991, 2002 and 2008, with Q exceeding 6.500 m^3/s.

The maximum flow is the cause of the most destructive slope processes and of the floods in the flood plain. Therefore, a quantitative evaluation (spatial and temporal) has not only a scientific importance, connected to the accelerated landform modelling (denudation, erosion, siltage), but also a significant practical importance, for designing all the hydro technical and hydro-ameliorative works.

High waters and high floods, as phases of the periods with high flow, occur in the warm period of the year (May - November) and they are produced by the combined effect of snow melting and spring torrential rains (mixed high floods), by the summer rains, and sometimes by autumn rains (simple high floods). Very seldom, floods can occur in winter as well (in December 1995, when liquid precipitations increased from 0.7 to 6.3 l/m^2 in 24 hours (25.XII), reaching a maximum of 35 l/m^2 on 27.XII.1995).

The maximum flow and the catastrophic high floods are generated by the summer rains, when the maximum flow of the rivers can be 2-3 times higher than the maximum spring values. As a consequence of the torrential summer rains, high floods with very high amplitudes can occur: July 1991, 27-28 June 1995; 2 July 1998; 5 June 1999; June 2006; July 2008.

The number of high floods varies according to the season, most of them occurring during spring, but also summer, and very few in autumn or winter. For the analysed period, the highest number of high floods was recorded in 1972, 1988, 1996, and the lowest number in 1985 and 1987.

The catastrophic high flood recorded in May 1970 was caused by a complex of factors simultaneously interfering in a long time interval. The releaser factor was represented by the intense liquid precipitation over large areas. Under such conditions, in Dragoşa station, the maximum flow had the value of 176 m^3/s (13.V.1970, 14^{15}hours). The spring high waters usually have two waves, very rarely only one. In this case, the first increase was less significant (85 m^3/s), generated by snow melting, and the latter increase was richer (176 m^3/s), with nivopluvial supply. A high flood of high intensity occurred in June, the same year, with a maximum flow of 231 m^3/s in Dragoşa.

In the case of the high flood recorded in July 1981, the first peak was higher than the latter. The main cause generating this high flood was represented by the high amount of precipitations. Under such conditions, the maximum flow of 245 m^3/s was recorded on 17th July, 15^{00} hours. The flow coefficient reached the value of 0.86. The intensity of the maximum flow was slightly higher than that of the high flood recorded in May 1970. The phenomenon can be explained by the higher intensity and duration of the rains in July 1981, when precipitations exceeded 35 $l/m^2/1h$.

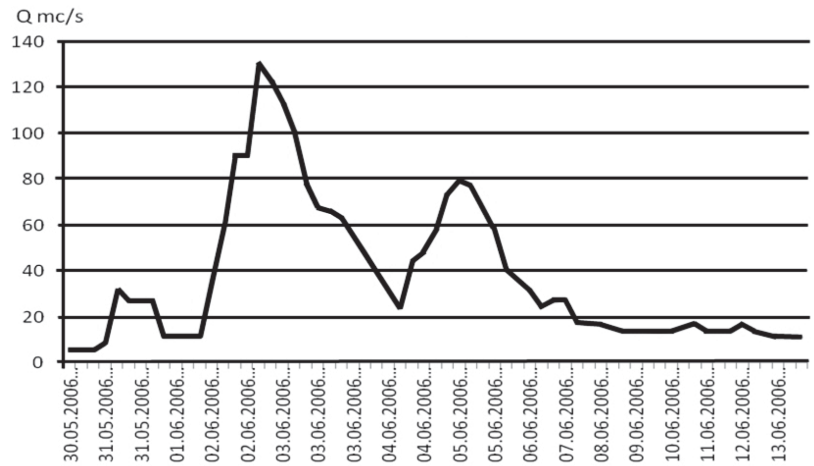

Fig. 2. ***Flow hydrograph in Dragoşa hydrometric station in 2006 – high flood 1***

At the station in Dragoşa, the total duration of the high floods varies between 80 and 322 hours, and the increase duration has values between 9 and 77 hours. The shape coefficients of the high floods have values between 0.10 and 0.32.

In 2006, the average flow of Dragoşa River was 6.300 m^3/s. The rain lasted from 30.05.2006, 07:00 hours to 13.06.2006, 17:00 hours. The peak of the high flood occurred on 02.06.2006, 21:00 hours, with a maximum flow of 130.0 m^3/s, and the height of the flow of 297 m (Fig.2).

On 14.06.2006, 07 :00 hours, the rains started, and they lasted until 22.06.2006, 17 :00 hours. The peak of the high flow was recorded on 15.06 2006, 21:00 hours, with a maximum flow of 134 m^3/s, and the height of the river of 300 m (Fig.3).

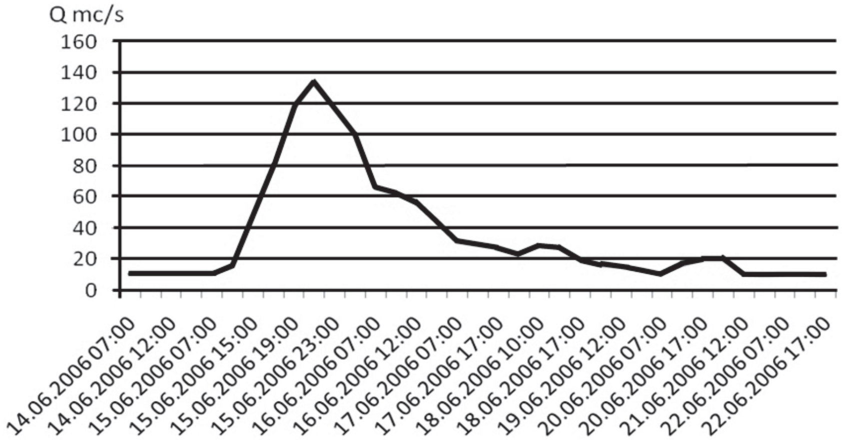

Fig. 3. ***Flow hydrograph in Dragoşa hydrometric station in 2006 – high flood 2***

At the station in Lunguleţ an annual average flow of 2.03 m^3/s was recorded in 2006. On 01.06.2006, 07:00 hours, the rains started and the lasted until 09.06.2006, 17:00 hours. The peak of the high flood was recorded on 02.06.2006, 21:00 hours, with a maximum flow of 41.3 m^3/s, and a water level of 218 cm. Five days later, a second high flood recorded, on 14.06.2006, 07:00 hours, which lasted until 22.06.2006, 17:00 hours. The peak of this high flood reached 40.7 m^3/s and the height of the river was 217 cm.

In 2008, at the station in Dragoşa, an average flow of 6.55 m^3/s was registered. The rains started on 23.07.2008, 06:00 hours, and they lasted until 08.08.2008, 06:00 hours. The peak of the high flood was recorded on 26.07.2008, between 17:00-18:00 hours. With the flows of 539 m^3/s, and 509 m^3/s respectively, and the level of 400 cm, and 390 cm respectively, this high flood was devastating, with immense losses in the flooded areas (Fig.4).

The latest floods in Moldoviţa river basin were recorded in the summer of 2008, more precisely at the end of June, 2008.

During the high floods in the summer of 2008, immense quantities of logs were transported and deposited in the flood plain. As a result, plugs were formed at the foot of the undersized bridges. The river basin is severely deforested and the flood plain hosts many houses, frame saws etc. The majority of the rural settlements in Moldoviţa river basin are situated in the flood plain.

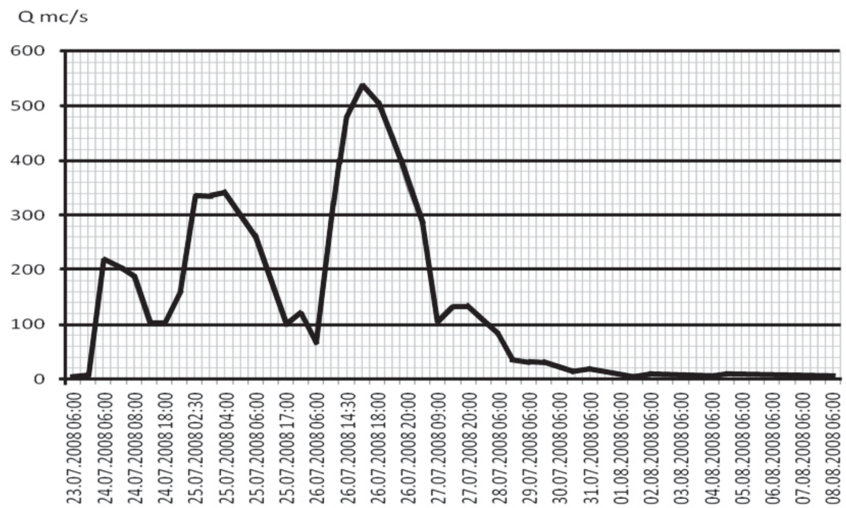

Fig. 4. ***Flow hydrograph in Dragoşa hydrometric station in 2008***

The simulations with GIS program demonstrate the high flooding degree of the settlements. The simulations were done for Paltinu and Râşca–Dărmăneşti Putna.

The localities of Râşca–Dărmăneşti Putna are crossed by Moldoviţa River and Săcrieş. When a 4-5 m high plug is formed, the water with the level of 4 m would flood entirely the inhabited area (Fig.5).

In the areas where the height of waters reached 1 m, the intra-village affected surfaces are as large as 5 ha, and the affected road network can be as long as 1.18 km. In the area flooded by the waters reaching the level of 4 m, the affected intra-village area would be as large as 45 ha, and affected the road network as long as 6.3 km. For a height of 5 m, 62.48 ha would be destroyed in the intra-village and the length of destroyed roads would be 9.09 km. Under such conditions, this area would be entirely destroyed by the high flood wave.

Paltinu village belongs to Vatra Moldoviţei commune and it is situated on the valley of Boului stream. For a level of 1 m, the effects are minor: about 0.41 km of roads destroyed. For a water height of 2 m, an area of 3.16 ha in the intra-village would be affected, as well as 0.92 km of roads. If waters reach a level of 4 m, the affected intra-village area would be significant, covering approximately 16.40 ha, and the length of affected roads would be 2.22 km.

5. CONCLUSIONS

Like any dynamic geographic system, the rivers in Moldoviţa river basin have reflected the connection with the climatic factors while recording such flow decrease or exaggerated level increase.

Located in a mountain area of the Eastern Carpathians, in the periods with precipitations exceeding the average, the flows of the rivers in Moldoviţa river basin increase, overflowing the banks. The high flood waves cause devastating floods in the settlements situated in the flood plains. Many years were recorded when high floods produced important material loss, affecting households, bridges, small bridges, commune roads, roads, railways, dams etc. The latest catastrophic floods in Moldoviţa river basin occurred on 26 July 2008, with the high flood wave recorded at 17:00 hours.

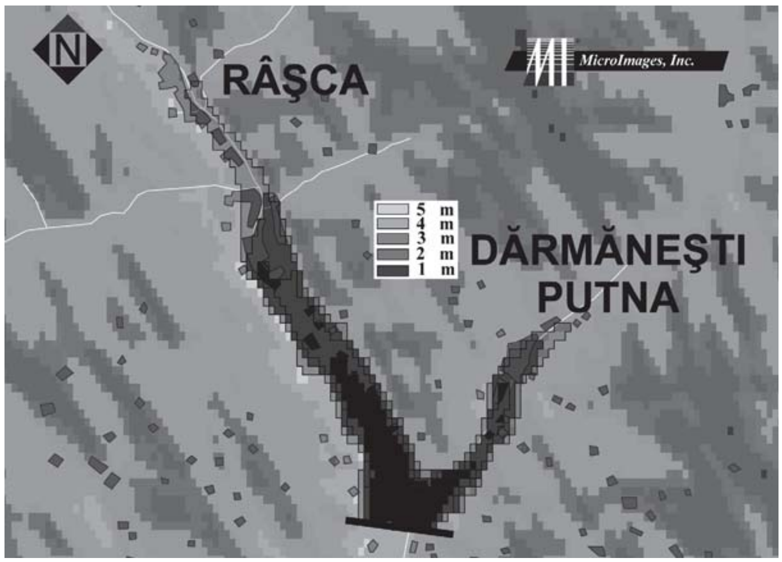

Fig. 5. ***Flood simulation in Râşca – Dărmăneşti Putna***

The high flood affected many households, social and economic buildings. Over 20 ha of agricultural land were severely affected in Vatra Moldoviţei. In the same village, the list with the loss can continue: 180 m of dams, footbridges, and a deposit for wood material. In Paltinu, the commune road was 70% damaged, two bridges were severely destroyed and the bridge defence collapsed over a distance of 50 m.

In order to defend the settlements, hydro technical works for regulating the flood plain were done and dams were built: works for defending and consolidating the banks, embankment works, water courses regularization and canalling works, works, works for fighting against depth and surface erosion, building up of bridges etc. Unfortunately, some of these works were undersized or they have a support pillar in the thalweg. This is why the plugs are formed so frequently, contributing to the formation of a barrage.

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