

HAZARDS, VULNERABILITY AND ASSOCIATED HYDROLOGICAL RISKS IN THE HYDROGRAPHICAL BASIN OF THE RIVER UZ, TRIBUTARY OF THE RIVER TROTUȘ

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ABSTRACT. – Hazards, vulnerability and associated hydrological risks in the hydrographical basin of the river Uz, tributary of the river Trotuș. As a consequence of the climatic change that has occurred in the last decade, the number of occurrences of extreme phenomena, follows an increasing trend with material and human casualties. The prevention of flash floods requires the complex and paramount importance action of responsible agencies. The river Uz is one of the most important tributaries of the Trotuș River; its basin has a high density hydrographical network. Using the data from the Basin Water Administration, Siret – Bacău, it has been possible to establish the flash floods' occurrence frequency, as well as their tendencies. Based on this information, the hazard maps were drawn together with the risk and vulnerability involved, thus fulfilling the objectives of the study; it substantiates that the flood risks increases in proportion with the decrease in altitude of the landscape, the densely populated zones are especially vulnerable.

Keywords: flash floods, floods, flows, levels, precipitations

1. INTRODUCTION

In the recent years, worldwide and in Romania, diverse natural or accidental highly risky phenomena have occurred. The floods have generated real disasters with human and material casualties. Due to this fact, the scientists have become more and more interested in drafting studies to analyze these phenomena. In 1971, Chow defined the flood as a rather big drain coming from rainfall which causes the water to come out of the river bed. Complex anthropic activities such as extended deforestation, irrational pasturage and plowing, make the drainage system to be even more torrential. The flash floods from 1978, 2004, 2005, besides other more extensive ones, are proof in this regard. In 2005, on the river Uz, at Cremenea hydrometric station, it was registered $Q_{\max.\text{historical}}=229 \text{ m}^3/\text{s}$ and at Dărmănești station it was registered $Q_{\max.\text{historical}}=129 \text{ m}^3/\text{s}$ (Basin Water Administration, Siret, 2013). The flash floods having occurred during that year, have devastated the area situated downstream the Poiana Uzului artificial lake from Dărmănești. The article studies an eventual occurrence of a fast and significant flow growth responsible for

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important geomorphological changes, devastating floods, as well as hydrological risks. The prevention of flash floods requires a complex and a significant action of all responsible agencies.

2. GEOGRAPHICAL POSITION AND CHARACTERISTICS

The hydrographical basin of the river Uz is situated in the eastern part of Romania. The river is the tributary of the river Trotuş and has its springs in the Ciucului Mountains. The surface of its hydrographical basin is around 475 km², its length is around 46 km. From a mathematical point of view, the surface of the basin is situated between 26° 00' 16" - 26° 30' 56" eastern longitude, 46° 08' 44" - 46° 23' 27" northern latitude (Basin Water Administration, Siret, 2013) (Fig. 1).

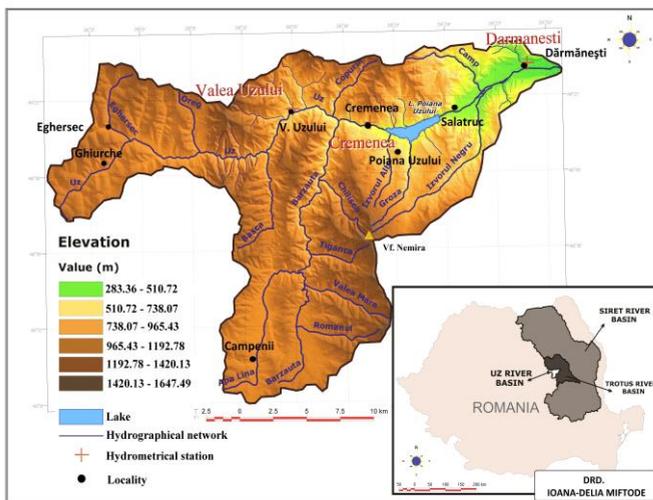


Fig. 1. Geographical position of the Uz river basin and of the gauging station location

From a geological point of view, the hydrographic basin of the river Uz is distinguished by the Cretaceous and Paleogene flysch zone in the mountainous sector and by the Neogene zone, in the depressionary zone, that is the post-tectonic zone. The tectonics of the zone, as well as the transversal profile of the river valley, has contributed to the formation of narrow

canyon-like sectors that alternate with small erosion basins. The main characteristic of the Uz valley is the presence of depressionary small basins and canyon like sectors with enormous detritus. The highest points are in the Nemira Mountains with the peaks Nemira Mare (1648 m), Nemira Țiganca (1626 m), Șandru Mare (1639 m), Osoiul (1553 m), Cărunta (1517 m). The North-South orientation of Nemira-Șandru Mare ridge directly influences the direction of the water drain. The inferior terraces are separated from the medium ones by accentuated slopes. The declivity of the slopes varies between 5° and 50°, in the meadow sectors between 1° and 3° and on the interfluves and on the terrace bridges the declivity values range between 0° and 6°. On the slope situated

between Bărzăuța River and Nasolea Mare waterfall, one can observe big fallen rocks. A peculiar climate can be found in this region, one which is specific to medium altitudes of the Oriental Carpathian Mountains, as well as a depression climate (shelter) which manifests in Dărmănești Depression. The hydrographical basin of the river Uz is characterized by a very dense hydrographical network in a mountainous area where the precipitations exceed 700-800 mm/year. The river Uz and its tributaries had a major contribution to the fragmentation of the landscape and to the creation of its current energy. The main right tributaries of the river Uz are: Bărzăuța, Izvorul Negru, Tulburea, Bașca, Groza, Izvorul Alb (which flows into the artificial lake of Poiana Uzului), and left tributaries are: Eghersec, Oreg, Rața, Soveto, Mogheruș, Copuria; in the lake flow the streams Rachitiș I and II, Plopu, Chitici, Câmpul, Boiștea. The artificial lake Poiana Uzului, situated on the Uz River, can be found at 13 km from the river mouth, at the outskirts of Darmanesti (Salatruc village) and at 31 km from the spring, is an anthropic reservoir used to supply fresh water to communities, generate electricity and diminish the flood flow within a small percentage. On the Izvorul Negru stream, tributary of the river Uz, the lake Bălătău was formed after and a land slide blocked the flow of the river bed. (Basin Water Administration, Siret, 2013).

3. THE DATABASE AND THE WORK METHODOLOGY

The analyzed data from this study, registered in the three hydrometric stations (Valea Uzului, Cremenea, Dărmănești) were obtained from Basin Water Administration, Siret – Bacău. Using the maximum annual flow (1977-2011), medium daily flow (2000-2009), medium annual precipitations (1989-2009), medium daily levels (2000-2009), different calculations were made. The frequency of flash floods occurrence was graphically determined, based on the data registered at hydrometric stations during various time intervals. In order to establish anytime, during a time period, when the maximum levels and flow values are occurring, the frequency diagrams of the levels and the flows were elaborated. Using the TNT Mips program, and based on the calculations and the use of the DTM (with the scale of 1:5000, a map zoom of 3 m) corresponding to the hydrographical basin of the river Uz, different risk maps were constructed. These maps were made using the flood simulation and the overlapping of different vector strata. In order to observe the evolution of the river bed and in order to estimate the shape of the water coverage during an eventual flood, transverse dams of various heights were imagined, situated along the watercourse. By applying the Weibull method and based on maximum flows, each having assigned different probabilities of overflow, it has been possible to establish the height of the dam used in the flood simulation.

4. RESULTS AND DISCUSSIONS

The diagram of the monthly flow frequency for the period 2000-2009 (Fig. 2), for the Valea Uzului hydrometric station, shows that the maximum flows occur most frequently in March and less frequently in April and July. For the Cremenea hydrometric station, the maximum flows occur with the highest frequency in April, while in March, June and July they have a lesser frequency. At Dărmănești hydrometric station, the highest frequency of the flows was observed in July and August.

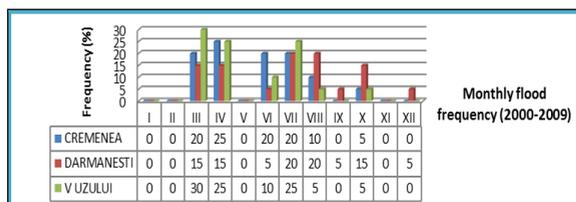


Fig. 2. Monthly frequency flow (2000-2009)

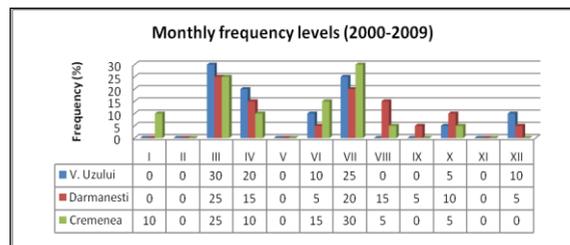


Fig. 3. Monthly frequency levels (2000-2009)

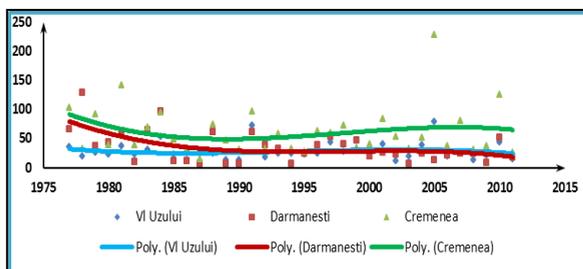


Fig. 4. Flow tendencies in the hydrographical basin of the Uz river (1977-2011)

summer, and by a specificity of the landscape with medium and low heights.

The flow tendencies for Cremenea and Dărmănești stations are fluctuating, while at Valea Uzului station the tendencies are constant (Fig. 4).

Analyzing the frequency of the levels (Fig. 3), one can observe that at Valea Uzului station, the maximum levels were registered mainly during March and July. The same months are valid for Cremenea and Dărmănești

stations. The simultaneous analysis of the two diagrams, the monthly flow frequency and the monthly level frequency for 2000-2009, confirms the existence of a correlation between the occurrence frequency of the maximum flow and that of the maximum levels. That is to say, approximately, maximum flows correspond to maximum levels. All the aspects presented above lead to the idea that the months during which occur most of the flash floods, in the studied zone, are the months of March, April and July. These phenomena are caused by snow melting, spring rain and torrential rains occurring during

When comparing the maximum levels tendency curves (Fig. 5) of all three stations, we observe that during 2000-2008 the ones for Valea Uzului and Cremenea are basically the same, while during 2002-2009 the Cremenea curve tendency coincides approximately with that of Dărmănești. From 2000 to 2002, at Cremenea and Valea Uzului, the annual maximum level values are higher than that of Dărmănești. During the period 2007-2009 the values of the maximum levels from Dărmănești are closer to those of Cremenea, but far lower than those of Valea Uzului.

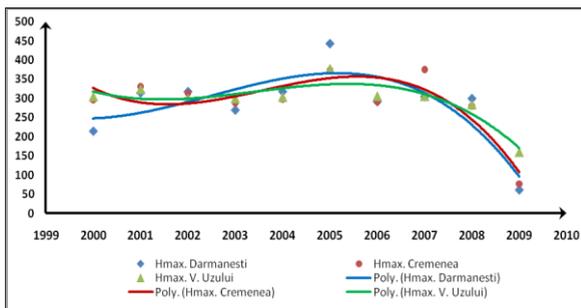


Fig. 5. The tendencies of levels in the hydrographical basin of the Uz river (2000-2009)

For Dărmănești hydrometric station, the precipitation tendency curve (Fig. 6) is similar to that of Cremenea up until 2004, but with lower values, while during 1997-2004 the two curves overlap. From 2004 until 2009, the tendency of the precipitations shows a moderate decrease in comparison with the Cremenea station

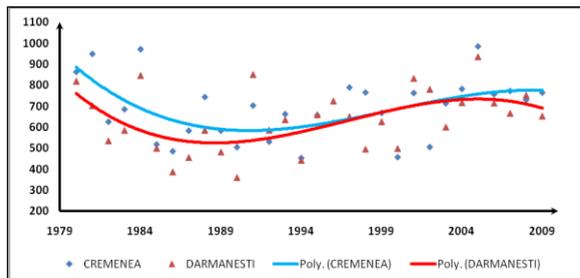


Fig. 6. The tendencies of precipitations in the hydrographical basin of the Uz river (1980-2009)

whose tendencies have a decreasing aspect.

Concerning the overall flow, level and precipitation tendencies, one can observe that at all the three hydrometric stations, during the periods when abundant precipitations occurred, the levels and the flows had increased values. It is possible to reconfirm the

proportionality link between precipitations, flows and levels.

In order to highlight the eventual flooded zones, a hazard map has been drawn (Fig. 7, 8) establishing the maximum flows with different exceeding probabilities, and analyzing the Pearson III empirical and theoretical probability curves (major risks correspond to low values of probability) (Table 1).

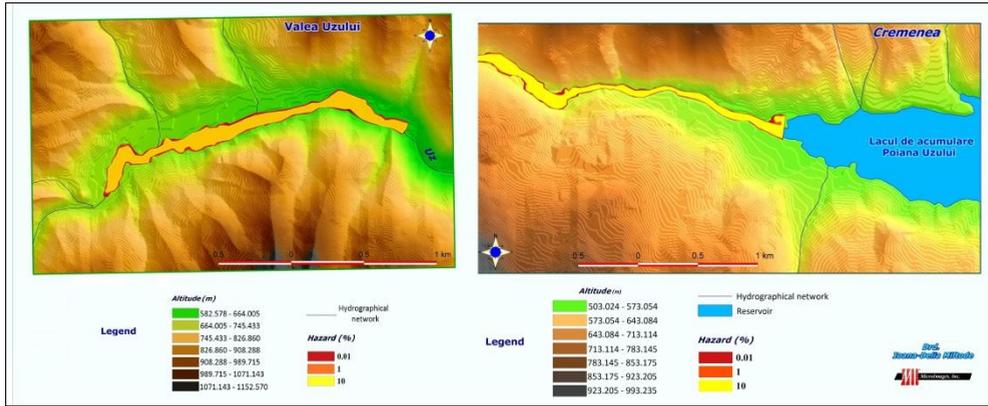


Fig. 7. Hazard map for Valea Uzului and Cremenea stations

Table 1. Pearson III probability in relation with the H_{dam} and $S_{probably\ flooded}$

(Fig. 7,8)	(Height of the dam; Probably flooded surface)		
$p\%$ (Pearson III probability)	Valea Uzului	Cremenea	Dărmănești
0.01%	(4.1 m; 37 ha)	(4.6 m; 20.48 ha)	(4.6 m; 279.7 ha)
1%	(3.8 m; 33 ha)	(4.3 m; 18 ha)	(4.3 m; 225.9 ha)
10%	(3.6 m; 29 ha)	(4.1 m; 16.4 ha)	(4 m; 184.7 ha)

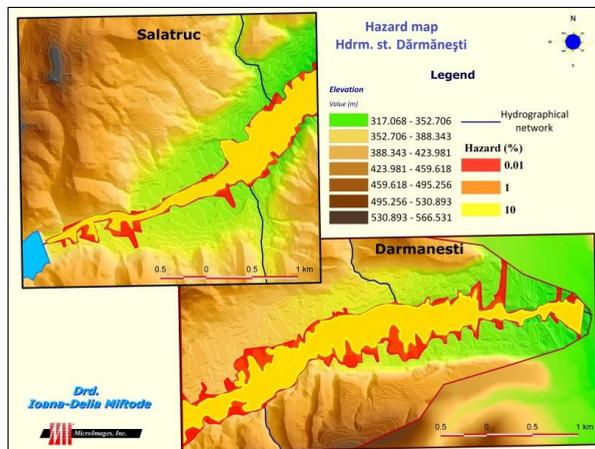


Fig. 8. Hazard map of Dărmănești station

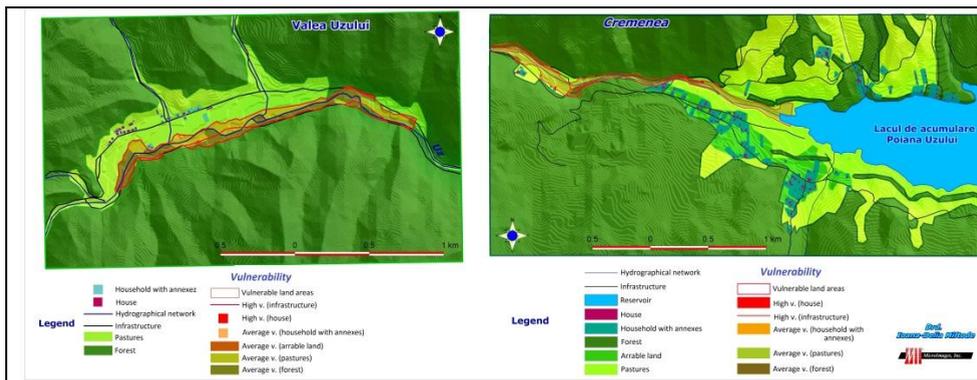


Fig. 9. The vulnerability map at Valea Uzului and Cremenea stations

The vulnerability map (Fig. 9, 10) emphasizes the vulnerable elements classified according to their importance. Upstream of Lake Poiana Uzului, there are mostly pastures and forests. The lower the altitude, the more the river extends its

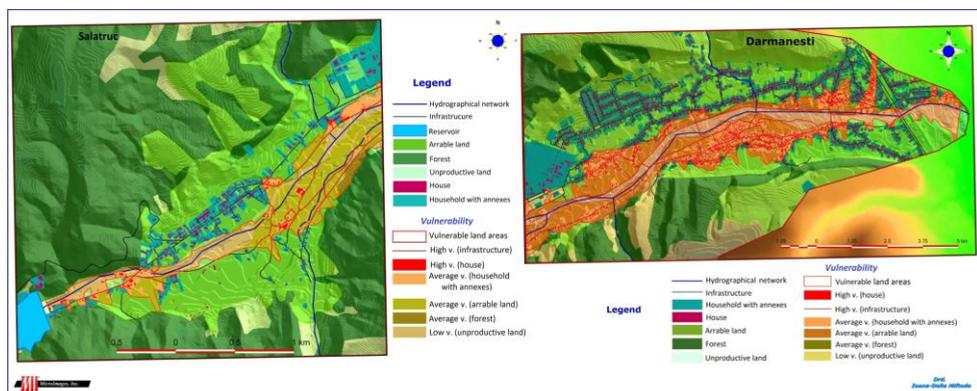


Fig. 10. The vulnerability map at Dărmănești station

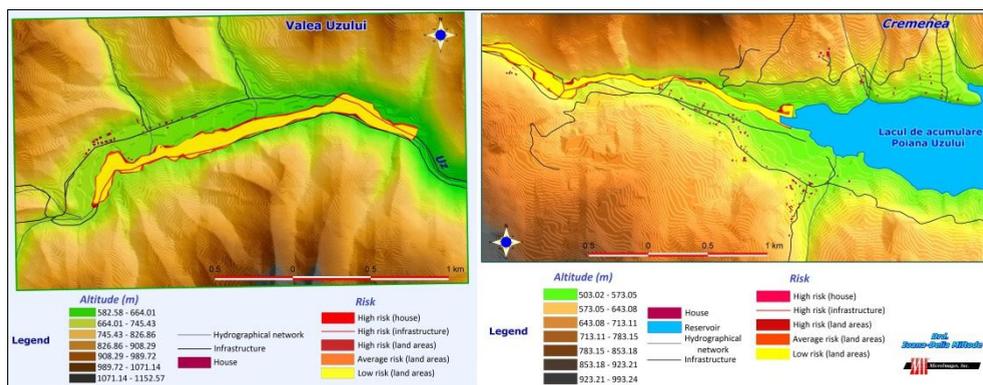


Fig. 11. The risk map for Valea Uzului and Cremenea stations

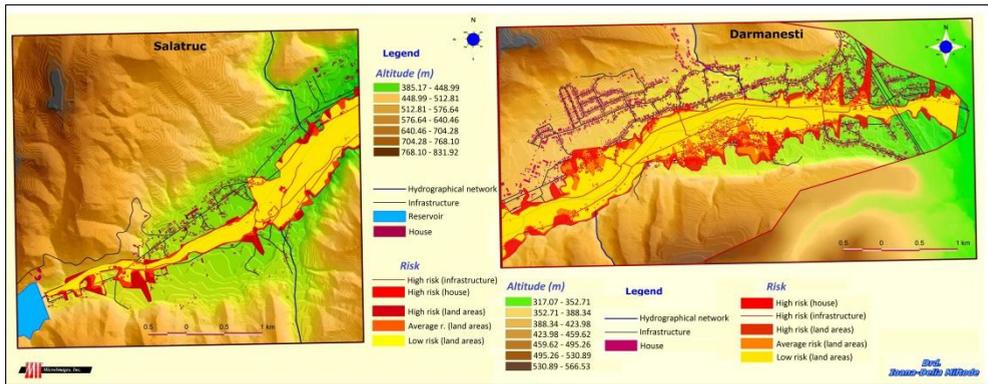


Fig. 12. The risk map for Dărmănești station

river bed, thus the vulnerability becomes greater, fact which is also due to urban crowding. The vulnerable elements of the areas related to the three hydrometric stations, are the access roads and the bridges. In the lowest altitude zones of the hydrographical basin, the households and the annexes, as well as the agricultural terrains, constitute vulnerable elements of this specific zone.

The risk is the probability that a person, a group of persons, a zone or a region to be in danger or to face a danger, or to bear a loss (Romanian Academy, 1975). The risk implies two main components in its definition: the natural and the human factor. The flood risk map shows the distribution of elements with high, medium and low risk. As seen in Fig. 11, 12, the elements exposed to the risk are represented by populations, buildings, infrastructure, environment elements and economic activities found in the action area affected by the hazard (Fell, R. et al., 2005). Same as in the case of vulnerability, the most numerous elements exposed to risk can be found downstream the Valea Uzului artificial lake due to the crowding phenomenon specific to the lower altitudes areas.

5. CONCLUSIONS

Resorting to a modern approach concerning the hydrological risk, through the use of design and instruments and identifying the methods through which the zones exposed to flood risk could be quantified, it has been possible to predict the occurrence of an eventual flood in the hydrographical basin of the river Uz. Thus the objectives of this study were fulfilled. The importance of the study would also consist in the possibility to verify the efficiency of hydro-technical constructions in the area, as well as in establishing prevention methods necessary to anticipate, prepare and develop risk action control in case of floods. It is also necessary to implement the protective measures whose aims are hazard reduction and the protection of the vulnerable elements. The risk control aspect relates to surveillance, alert and population sheltering. The economic evaluation presents a

special significance, permitting the orientation and evaluation of public policy concerning risk prevention, as well as taking care of the due-diligence for the principles of risk reduction.

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