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THE ANALYSIS OF THE FLASH FLOODS OCCURRED IN THE UPPER BASIN OF TELEAJEN RIVER

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Abstract

The study aims at the knowledge of the liquid discharge regime features in the upper course of Teleajen hydrographical basin. The shape of the basin is considered to be the result of the drainage action under certain conditions of: lithology, tectonics, climate, vegetation. This has a round shape, close to a square, and the flash floods form and flow rapidly in 3-9 hours, determining a high power of transportation and erosion. The paper herein studies the flash floods from July (1975 and 1991) and September (2005) on the upper course of Teleajen, at the Cheia hydrometric station, on a surface of 41.7 km². The flash floods analysis shows that these were fast flash floods, the maximum flows having an excess probability of 5 - 10%. The occurrence of flash floods and their features are also determined, according to other factors as well, besides the climate conditions (precipitations, temperatures and wind), such as: permeability, humidity degree, soil temperature, river bed slopes and mountain slopes, shape and surface of the reception basins and the river bed features, and according to the anthropogenic factors: the massive deforestation, the extension of human settlements and infrastructure.

Keywords: flash flood, flow, morphometric features, environment factors.

1. INTRODUCTION

This paper aims to identify the causes of the fast flash floods occurrence and their integrated management, having as purpose the limitation of damages and the remedy of the problems occurred following these calamities in the upper basin of Teleajen. The main objective of the paper is to identify the space and time dimension of the risk hydrological phenomena (fast flash floods and floods) in the upper basin of Teleajen.

The upper basin of Teleajen River is found in the south-eastern part of Romania, on the southern slope of Ciucaş Massif, which forms part of the Curvature Carpathians Group. This basin is formed of the hydrographical sub-basins of the Berea and Gropşoarele streams, which join downstream from Cheia locality, forming the Teleajen River (figure 1).

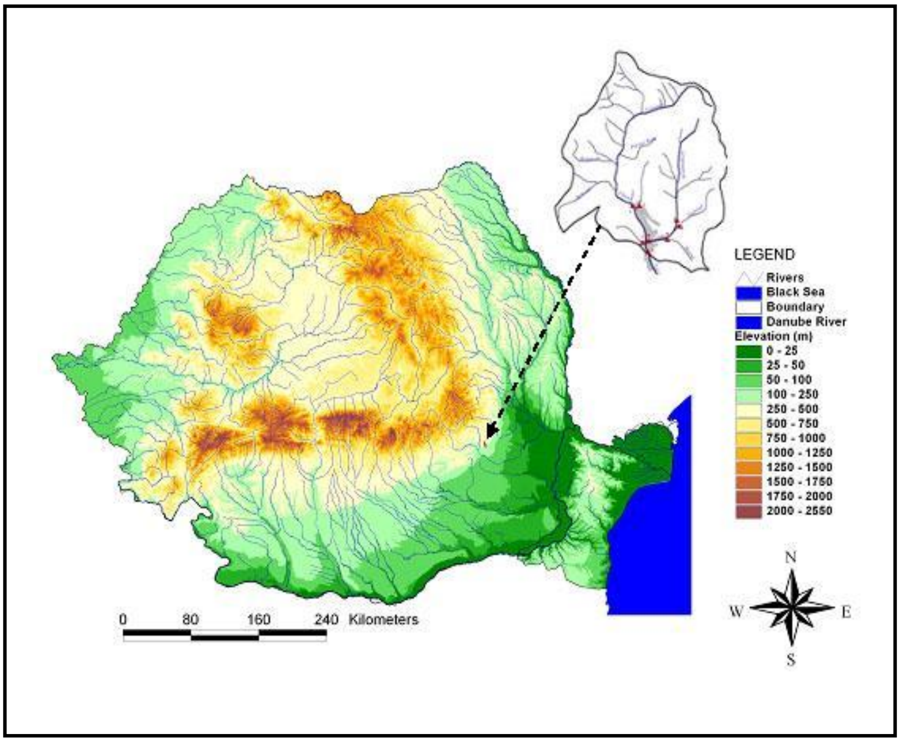

Figure 1. Locating the upper basin Teleajen in the country - As Cheia Projects in 2006

2. METHODS

The data based on which the study herein has been drawn up are the values of the flows measured at the Cheia hydrometric station on the Teleajen River (1960-2012), as well as the use of climatologic and meteorological data.

This study uses as methods: the geographic description, the map analysis, the morphometric and morphological analysis of the relief, and the statically - mathematical methods for the analysis of fast flash floods, of the maximum liquid discharge and the determination of flash flood waves.

3. RESULTS AND DISCUSSION

3.1 Geology: According to geology, the studied area is classified in the internal flysch area of the Eastern Carpathians, in their southern extremity. Ciucaş Massif comprises a well-individualised area compared to the neighbouring regions, due to the geological structure, the petrographic relief (klipps developed on limestone) and the structural relief (figure 2)

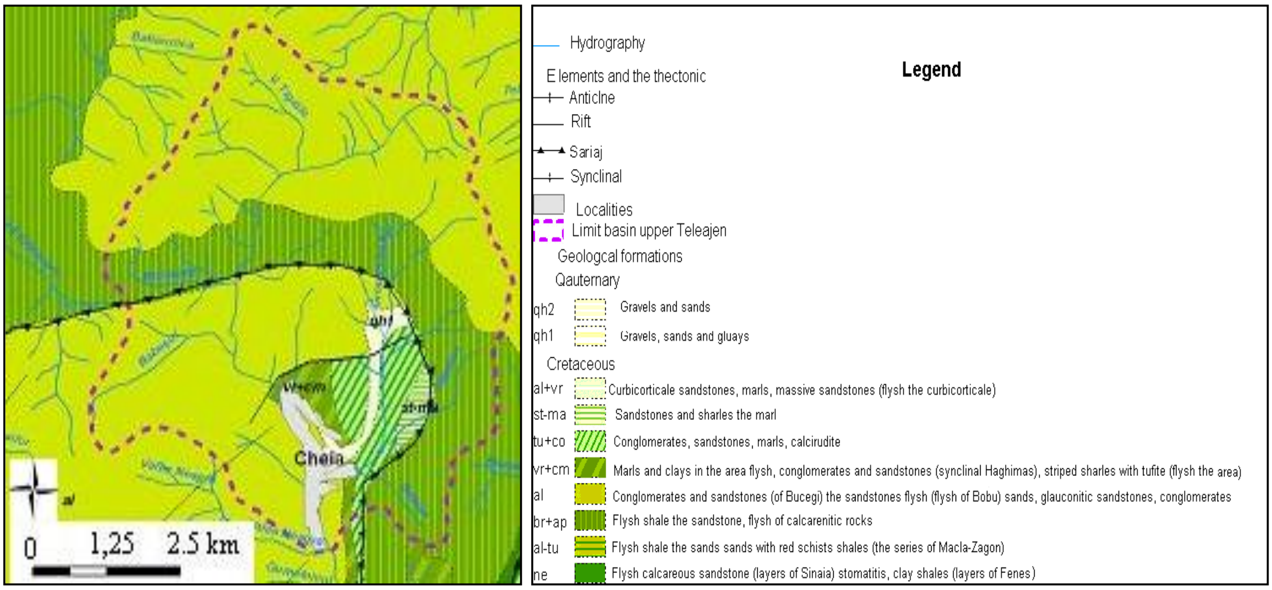

Figure . 2 The geological formations from the upper basin of Teleajen
(according to the geological map of Romania, scale 1:200000, Sheets of Braşov and Covasna)

Mountain peaks: Zăganu (1817 m), Colţii Nitrii and Ciucaş Massif comprise formations of Teleajen strata, with clays and sand stones folded in a set of synclinals and anticlinals. Canyons are formed in limestones and conglomerates on some of the tributaries of Teleajen (Cheiţa, Valea Stânii). *The high step* of the relief, located between (1400 – 1954 m), corresponds to a pile of conglomerates from Bucegi with a large thickness (500–600 m), of albian age (al+vr) and to the flysch from Bobu (al). These conglomerates are formed of sands, grabble and round elements of crystalline schists, gneiss, sandstones and limestones, connected through sandy limestone cement.

The middle step of Ciucaş Massif is located between 1000-1200 m. This corresponds to less resistant rocks, a variation of sandstones, clays and clay schists of Barremian-Aptian age (br+ap), deposited during the Lower Cretaceous (V. Mutihac, M. I. Stratulat, R. M. Fechet, 2004).

The low step is formed of various less resistant rocks, such as marl and clay schists, curbicortical conglomerates and sandstones (tu+co, al+vr, vr+cm and st+ma) belonging to the Middle and Late Cretaceous and Quaternary, as age (qh1) – formed of sands, grabble and clays.

3.2 Relief: Ciucaş Massif is formed of two main peaks: a) Bratocea Peak – Ciucaş (1954 m) with its SV – NE direction and b) Gropşoarele Peak – Zăganu (1883 m), with its NV – SE direction. These peaks are connected in the north through the saddle of Chiruşca Mountain and a lower peak presenting smooth straight surfaces, which are deforested, with altitudes between (1500–1600 m) and separated in the south by Teleajen River, on its upper course, by Berea stream. The altitudes vary between (848–1954 m) on the upper basin of Teleajen River. The maximum altitude is the Ciucaş Peak (1954 m), and the average altitude of the basin is of 1405 m. Ciucaş-Buzău Mountains belong to the low Carpathian units, presenting large valleys and terraces, with wider areas of the basin due to the different erosion, especially around Cheia locality. The average slope of the river is high, this reaching (78 m/km), indicating a high erosion potential (figure 3).

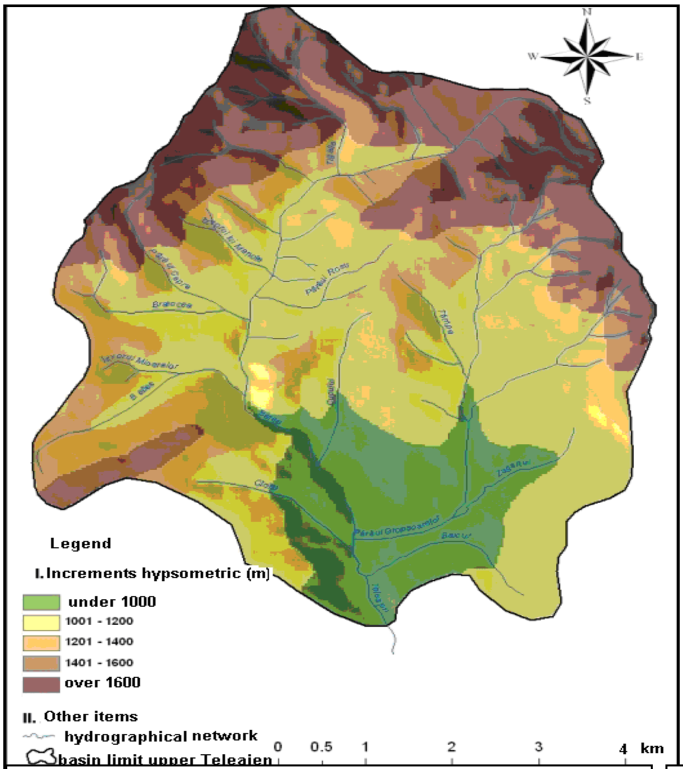

Figure 3. The hypsometric map of the upper basin of Teleajen.

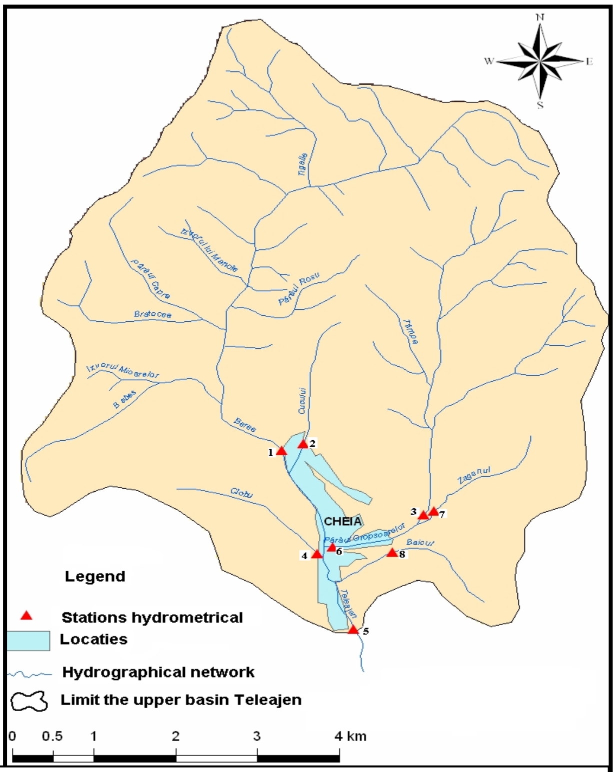

Figure 4. The distribution of the hydrometric stations within the upper basin of Teleajen

3.3 Morphometric features in the upper basin of Teleajen

The upper basin of Teleajen presents the following morphometric elements of the basin: surface (41.7 km^2), length (7.5 km), maximum width (7 km) and the river length is of 11.2 m.

Regarding the basin shape considered being the result of the drainage network action under certain conditions of lithology, tectonics, climate and vegetation, this has a round appearance, downstream of Cheia locality, after the confluence of Berea and Gropşoarele stream, Teleajen River being classified in the 4th order in terms of size, according to the Horton-Strahler hierarchy system. The current appearance of the basin was determined by the repeated modifications of the basic level represented by Prahova River.

For the upper basin of Teleajen River, ***the shape index,*** set forth by Gravelius as a ratio between the basin perimeter (P= 27.7 m) and the perimeter of a circle with the same surface like the one of the basin r = 3.65, K = P/2πr is of 1.21, and ***the shape factor*** $F_f = F/L^2$, where *F* and L represent the basin surface, the shape factor F_f has the value of (0.74).

To have a real image of the basin shape as possible, **the shape ratio,** having as reference the square *Rf =S/(P/4)² =0.87*, shows that the waters of the tributaries reach the geometric centre of the basin at the same time, and the flash floods quickly form and flow, determining a high power of transport and erosion. ***The dilation ratio,*** as a ratio between the diameter of the circle with an equal area and the length of the basin, R= 3.65, D=7.30, Ra = ΦCS/L = 0.97.

The circularity ratio may be calculated as a ratio between the surface of the basin and Scp - the surface of a circle with an equal perimeter with the one of the basin (S= 60.06 km²; r= 4.41), according to the formula: Rc = Sb/Scp, for this basin Rc=0.68. All these values of the shape indexes show the high degree of basin roundness (Zăvioanu I., 2005).

3.4 The hydrographical network of the upper basin of Teleajen River

Teleajen River springs from Ciucaş Massif, north of Roşu peak, at an altitude of (1754 m).
It receives numerous small tributaries in its upper sector, on the right side, such as: Tigăile stream, Izvorul lui Manole, Bratocea and Babeşul stream, while, on the left side, Berea stream (9.89 km) receives Roşu and

Valea Cucului streams as tributaries. Downstream from the confluence with Babeş stream, Berea stream crosses a narrow sector, a canyon, bearing the name of Cheiţa. Gropşoarele stream (6,35 Km) springs from the southern part of Roşu peak, at an altitude of (1750 m). It receives as tributaries, on the right side, Fugarilor, Tâmpa streams, and, on the left side, Gropşoarele-Stână, Izvorul lui Cârstocea and Zăganul streams. After the confluence of Berea and Gropşoarele streams, Teleajen River receives Ciobul stream, as tributary on the right, and Baicul stream, as tributary on the left. A series of experimental hydrometric stations have been set up on the upper basin of Teleajen, (figure 4) describing their morphological elements:

Table 1. The hydrometric stations within the Cheia experimental basin (Cheia Project, Gis)

Founding year	Hydrometric station	River	Surface (km²)	Average altitude (m)	Average slope m/km or ‰
1975	Cheia 1	Cheiţa	19	1320	397
1975	Cheia 2	Cucu	1.10	1096	291
1975	Cheia 3	Tâmpa	10.8	1213	270
1975	Cheia 4	Ciobu	1.30	1085	292
1975	Cheia 5	Teleajen	41.8	1263	339
1995	Cheia 6	Gropşoarele	6.80	1290	376
1995	Cheia 7	Zăganu	2.20	1073	182
1995	Cheia 8	Baicu	1.10	1004	42

3.5 Morphometric features of slopes in the upper hydrographical basin of Teleajen

The slopes vary between (5 º - 56 º) within the upper hydrographical basin of Teleajen. The slopes with lighter inclinations are located on the upper courses of Berea, Tigăilor, Bratocea and Babeş streams, where the relief energy and the erosion processes have a lower intensity. The slopes with higher inclinations (41 º - 56 º) are present in the western, northern and north-eastern parts, on the highest mountain peaks: Bratocea, Ciucaş and Roşu Mountains, representing greater relief energy. The lowest values of the slopes (5 º - 10 º) are characteristic of the central and southern parts of the basin.

3.6 The climatic factors determining the surface discharge: **a)** ***Precipitations*** in Ciucaş Massif are relatively abundant, but show variations regarding their distribution according to the season. The average annual precipitation quantity varies between (1200-1350 mm). During the cold season of the year, the precipitations decrease to 350 mm/month, at Cheia, and 400 mm/month, on the peaks, and, during the warm season, these reach 500 mm/month, at Cheia, and over 600 mm/month, on the peaks (Sălăjan L.,2010).

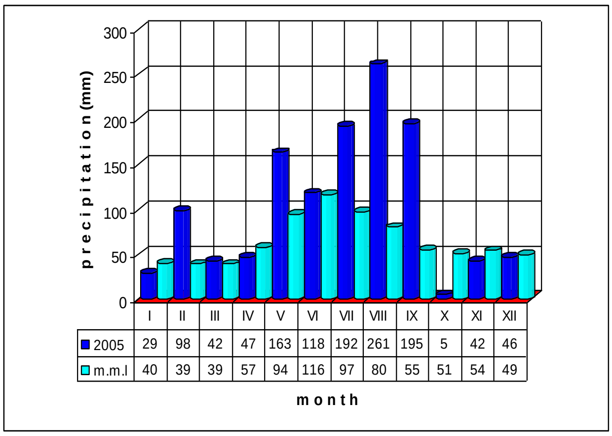

Figure5. Monthly average precipitations from 2005 compared with the monthly multiannual averages at the Câmpina meteorological station

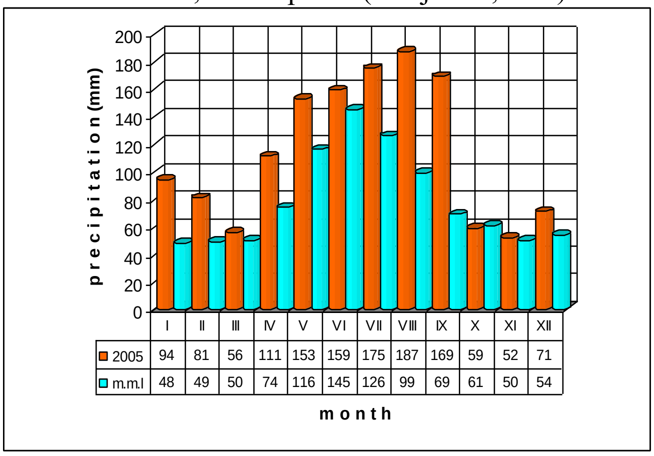

Figure 6. Monthly average precipitations from 2005 compared with the monthly multiannual averages at the Predeal meteorological station

Their analysis was performed at the Câmpina and Predeal meteorological stations at the border of the analysed basin: At Câmpina, the monthly average precipitations from 2005 compared with the multiannual average precipitations are similar, except for the month of October recording the lowest value, in the following months: February, May, July, August, September recording values over 50 - 80 mm (figure 5.). At Predeal meteorological station, we notice that the monthly average values from 2005 are similar with the multiannual averages, in the following months: March and October - December, and, during the rest of the months, the precipitations are 50 mm higher than the average (figure 6).

b) Temperatures: Ciucaş Peak is characterised by annual average temperatures (1 - 2 °C), while the annual average temperature is (4 °C) at Cheia. In winter, the average of January has values comprised between (-8 and -9 °C) on the peaks and (-6 °C) at Cheia, and, in summer, the average of July is (10 - 12 °C) on the peaks and (15 - 16 °C) at Cheia.

The thermal convection phenomenon occurs during summer, being able to lead to the heavy rainfall producing fast flash floods (ANM).

3.7 Soils: The upper basin of Teleajen is characterised by ***cambisoils,*** these being homogenously distributed and representing 70.54 % from the analysed surface. ***Spodisoils*** represent 6.2 %, ***luvisoils*** represent approximately 18.51 % from the basin surface, while the soils that are not specific of the area (***undeveloped, truncated or drained***) occupy approximately 7% from the basin surface and are present in the southern and eastern parts, on steeper slopes and in the Teleajen meadow (GIS).

3.8 The vegetation within the upper basin of Teleajen is specific of the forest area, and it is distributed on steps according to the altitude, approximately 75% from its surface is occupied by forests (figure 7). *The coniferous forests* represent 14 %, *the mixed forests* are found in the southern and south-eastern parts and represent 12% from the basin surface, while *the broadleaf forests* represent 49 % from the basin surface. The distribution and the features of the various types of forests have been largely influenced by the people's activity, because of the irrational exploitation of wood, especially in the north - eastern part of the basin. *The natural and secondary meadows* represent approximately 14% from the surface of the basin, showing different stages of degradation. The subalpine vegetation is present above the forests step, in Roşu and (Zăganu and Bratocea) Mountains.

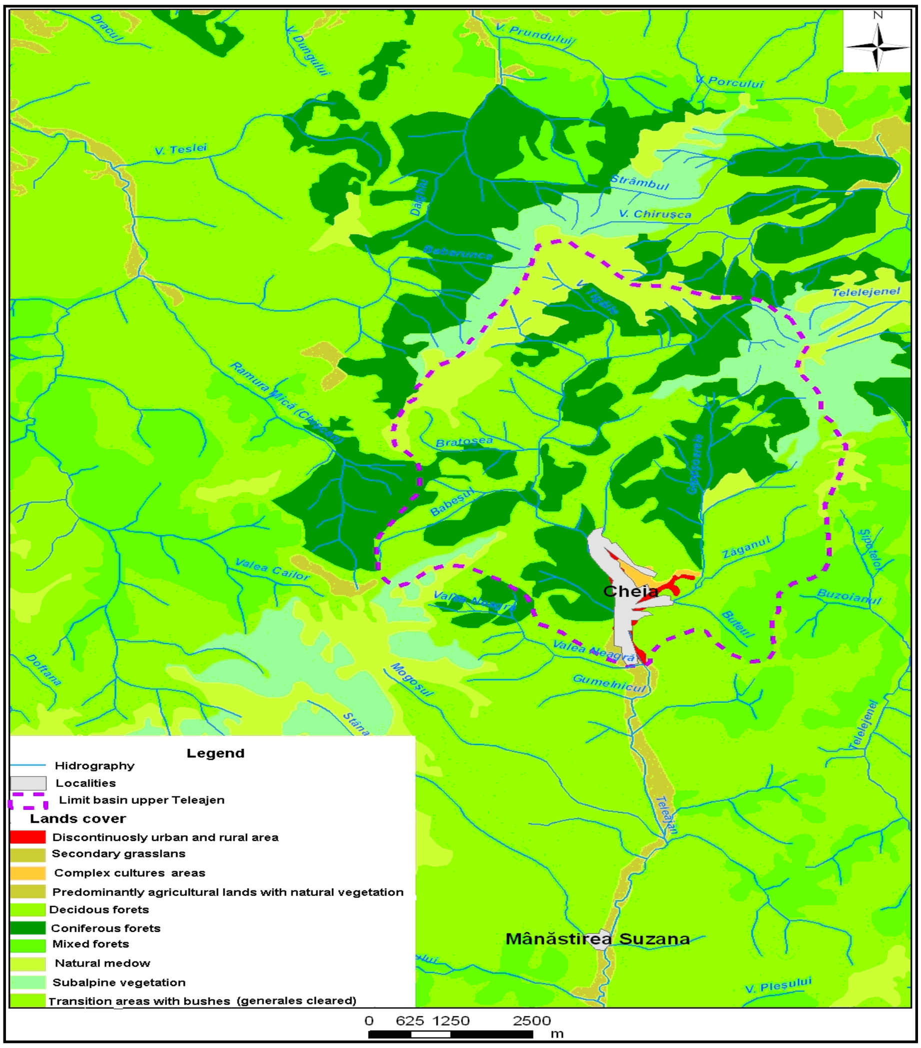

Figure 7 The map of land coverage in the upper hydrographical basin of Teleajen

3.9 Flash floods and floods as effects of the environment factors. The occurrence of flash floods and their features are determined by other factors, besides the climate conditions (biotope vectors), such as: permeability, degree of humidity, soil temperature, river bed and mountain slopes, the shape and the surface of hydrographical basins and the river bed features. The smallest the basin is, the higher the relief energy is, the intrinsic factors of the basin biotope (the geological, paedological structures, the vegetation coverage degree) offer a negative feedback and the destructive redundancy is emphasised, and the consequences on the environment are huge. The anthropogenic factors have an important role in the occurrence of fast flash floods: the massive deforestation, the extension of human settlements and the infrastructure (Cheia Project, INHGA, 2006). The fast flash floods endanger the human lives, produce material losses and have negative actions on the ecological factors (water contamination, soil, slope erosion and landslides).

Photo 1: Upper Teleajen in 13 July 2010 (http://www.realitatea.net/)

3.10 Flash flood features on the upper course of Teleajen River

This basin is characterised by the bimodal flash floods during summer, which can be explained in terms of the cloud front that is travelling from the mouth to the springs, thus producing a discharge from the tributaries that are closer to the closing section, the second peak coming from the travelling of the front forward to the exit from the basin. We notice that the rains in this basin, during summer, are formed of two nuclei, the first one with a smaller rain quantity than the second one, but within a shorter interval, of 1 - 3 hours, compared to the second nucleus, comprised between 6 - 9 hours, making the rain intensity higher than the one from the first nucleus. This determines the first flash flood peak with a lower growth time than the one from the second flash flood, but also smaller durations of the flash floods than the ones of the second one. According to the discharge, the higher intensity of the rain has as consequence the increase of the discharge speed on the slope, the reduction of the concentration time, thus, the reduction of the flash flood duration and the increase of its peak. The high intensity of the rain, combined with the relief energy and the lithological structure, also favours a more accentuated engagement of the solid, determining the increase of the turbulence degree. These flash floods occur on the deforested slopes with steep inclinations, because of the sudden melting of the snow layer or the torrential nature of the rains.

The assurance of real time warnings imposes a fast evaluation of the precipitations received from the automatic stations, the radar information and the comparison of these precipitation values with various critical thresholds associated to the preset defence rates. The connection between the precipitation thresholds, leading to the reaching/excess of the defence rates in the sections controlling the smaller basins with torrential regime, may be determined based on the correlation of the flash floods features with their triggering factors (Cheia Project, INHGA, 2006). Upon the prediction or the record in the operational service of these preset values, warnings can immediately be issued to the decisional factors, estimations can be made regarding the severity and the risk of the event as well as the maximum flow of the flash floods according to the precipitation fallen or estimated. The precipitations that determined the flash floods from this hydrometric station were: in 1975 (193 mm) and the maximum precipitation in 24 hours (133 mm); in 1991 (120 mm) and the maximum precipitation in 24 hours (75.2 mm); in 2005 (246 mm) and the maximum precipitation in 24 hours (167 mm). Thus, the flash flood wave elements for 1975 were graphically represented and determined in (figure 8 and table 2).

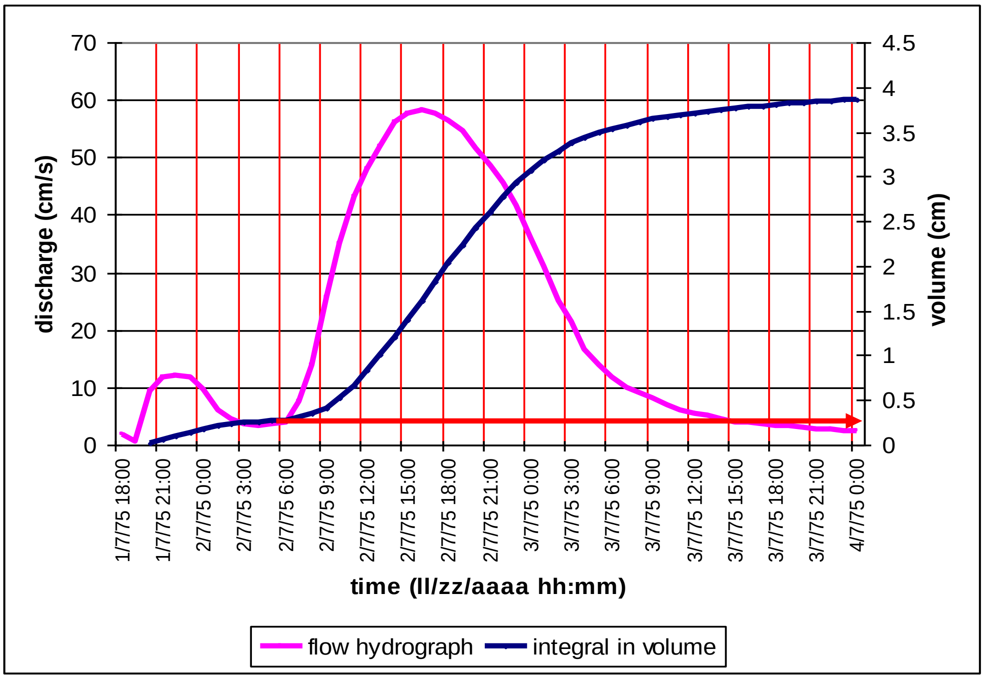

Figure 8. The flash flood on Teleajen River at the Cheia hydrometric station (1- 4.07.1975)

Table 2. The flash flood features on Teleajen River at the Cheia hydrometric station (1- 4. 07.1975)

	flood 1	flood 2	units
Growts time	3	9	hour
Deacrease time	7	30	hour
High food duration	10	39	hour
W-flood volume	0.25	3.61	cm
W-basic volume	0.068	0.36	cm
Qmax -discharge	12.1	58.3	cm/s
Basic discharge	1.9	2.85	cm/s
Specific flow	29	87	l/s&kmp
Basin area	41.3	41.3	kmp
Form discharge	0.57	0.44	
Coeff.discharge	0.21	0.54	
precipitation	30	160	mm

3.11 The discharge features on the upper course of Teleajen River at the Cheia hydrometric station

The analysis was performed on the upper course of Teleajen River at the Cheia hydrometric station, characterised by the following morphometric data: F = 41.3 km^2 , H_{med} = 1263 m and I_{bm}= 339 ‰ (Cheia Project, INHGA, 2006). This hydrometric station was set up in 1952 and the analysis of the average discharge was performed for the period (1960-2012). Teleajen has an average flow of 0.79 m^3/s, the maximum flow recorded was of 83 m^3/s in 1970, having the excess probability of 5%, and the value of 58.3 m^3/s during the period (1-4.07.1975) was the second one from the values with the excess probability of 10 %, flash flood occurring every 10 years. The maximum flows with various probabilities at the Cheia hydrometric station on Teleajen River are: 1% - 148 m^3/s; 2% - 124 m^3/s; 5% - 80.0 m^3/s; 10% - 55.0 m^3/s (The Cadastre of Waters and Maximum Flows from Romania, 2002).

3.12. Determining the assurance curve at the Cheia hydrometric station on the upper course of Teleajen River

In order to execute engineering works with water usage, flood protection purposes, the assurance curves have a special importance in providing the flows used in the sizing of these works. In the hydrological practice, the most important assurance curves are determined according to distributions of the Weibull, Kriţki Menkel, Pearson III types. The theoretical *Pearson III probability curve* is obtained with the formula $Q_{p\%} = \overline{Q}\left(1 + C_v\ \phi_{p\%}\right)$, where $\phi_{p\%}$ represents the ordinate deviation of the probability curve corresponding to an excess probability of p%, determined through the coefficient interpolations (from tab. 10.4.1- 10. 4,5, and fig.10.4.1, according to Drobot R., Şerban P., Roman P. 1999). To analyse the maximum flows from the Cheia hydrometric station on Teleajen River, the maximum flows from (1960 - 1992) were analysed and the Pearson III theoretical and empirical curve was determined (Cv = 1.60, Cs = 3.80 and Cs/Cv = 2.38) in figure 9.

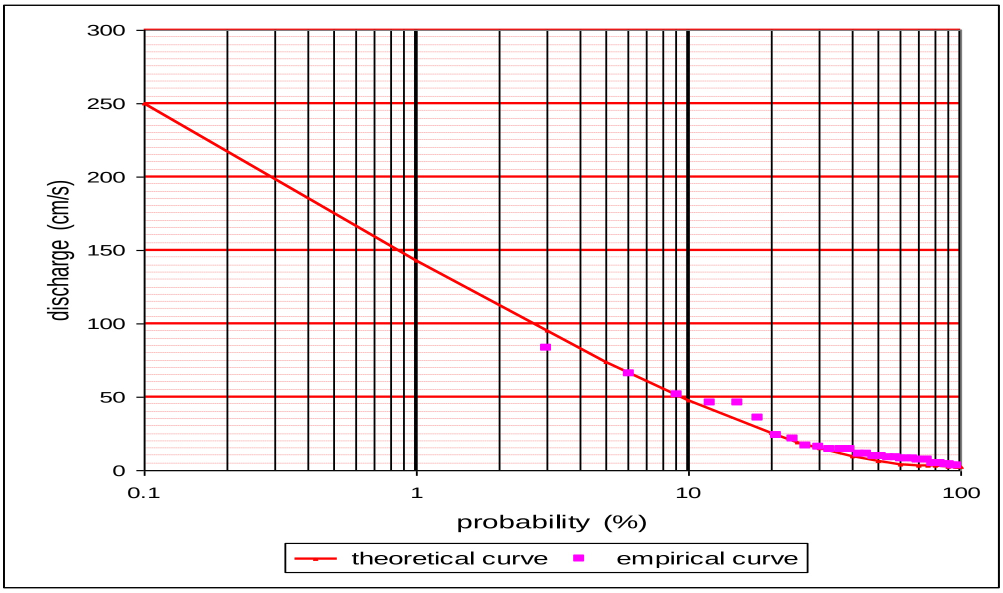

Figure 9. Pearson III theoretical and empirical curve at Cheia on Teleajen River

CONCLUSIONS

By analysing the upper basin of Teleajen according to its geology, geomorphology, lithology, climate and hydrology, we have found out that the flash floods are fast, with growth times between 1 - 9 hours, which can be translated in smaller concentration times on slopes, because of deforestation, the lack of agricultural and forestry works or the execution of improper works. The almost round shape of the analysed basin determines the fast concentration of waters in the geometrical centre of the basin, producing fast flash floods with a higher power of transport and erosion. The times are favoured by the high inclination energy, the lithological structure and the high intensity of precipitations, determining a high turbulence triggering the displacement and the carrying of solid particles, thus recording high solid flows (64 kg/s during the flash flood occurred in 2005) with the increase of the quantity of deposits.

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