THE FLOOD RISK IN THE IALOMITA RIVER BASIN CASE STUDY: THE JULY 1975 FLASH FLOOD

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ABSTRACT. **Te flood risk in the Ialomita river basin case study: the july 1975 flash flood.** Since over the last four decades the Ialomita River Basin has been affected by several catastrophic hydrological events, of which the most important were the ones in 1975, 2001 and 2005, for a better management of the extreme situations generated by such episodes we propose a new methodology regarding the estimation of the flash-flood appearance potential in this particular river basin, as well as an analysis of such an event that occurred in July 1975 and affected large swaths of the geographic area we have taken into consideration. In order to identify the regions which are vulnerable to the processes caused by slope run-off we have used the Flash Flood Potential Transmission Index (FFPTI), first proposed and used by Smith (2003) in the "Western Region Flash Flood Project" (WRFFP) and then by several researchers from Romania, such as G. Minea (2011), M. Mătreaţă (2011) and M. Borcan (2011). The main purpose of this method is the estimation of an index that would synthetically express the flash-flood potential for both a major river basin (such as Ialomita River Basin) as well as for a minor river basin (usually sub-components of major river basins). The quantification of the impact that the major physical-geographic factors (slope, soil texture and land use) and the main run-off causing factor, rainfall, have gives the magnitude of this flash-flood potential transmission index.

Key words: flash-flood potential transmission index, risk classes, Ialomita River Basin, July 1975 flash-flood and maximum rain-fall.

1.Introduction

Flash-floods are natural phenomena that ought to be considered normal events in the liquid flow of an organized hydrographic network, representing the peak discharge moments in the evolution of the liquid flow on a river. Depending on their magnitude, flash-floods can trigger major flood events, as it usually happens when water exceed the limits of the riverbed. In 1978, Ward (quoted by Grecu in 2006) defined the flood event as being *a volume of water that covers an area which is usually emerged*.

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In 1978 Zavoianu stated that the "*flooding area represents a low-land area that may be easily sub-merged when water levels of a river increase*".

The Ialomita river basin is located in south-eastern Romania, between 25°40' and 27°09' E and 44°32' and 45°32' N. Between these mathematical boundaries the Ialomita river basin displays an elongated shape from north-west towards south-east, stretching along 2°31' of longitude and 1° of latitude.

Within this area, the Ialomita river basin exhibits all the three major landforms, each with its own characteristics, starting with the mountainous region in the northern part of the basin and decreasing towards the hills region in its median part and the plain region in its southern and eastern reaches.

2. Fash-floods and their favorizing factors

The main cause for the appearance of flash-floods in the Ialomita river basin is represented by rainfall, which must have the following characteristics:

- high quantities over a short period of time;
- high intensities over a short period of time;
- a uniform spatial distribution (Mustățea, 2005).

A very important characteristic of the pluvial regime is ***the maximum amount of rain fallen during a 24-hour period***, which can intensify the slope run-off and thus cause flash-floods.

These heavy rain episodes usually occur over a short period of time and cover small areas. They are also very unpredictable.

The analysis of the maximum amount of rain fallen during a 24-hour period was achieved using the data from the most important weather stations located thorough the basin, for the 1961-2007 interval (Table 1).

Table 1. Maximum monthly 24-hour rainfall amounts in Ialomița river basin (1961-2007)*

Weather station	Months												Year
	I	**II**	**III**	**IV**	**V**	**VI**	**VII**	**VIII**	**IX**	**X**	**XI**	**XII**	
Vf. Omu	**35.1**	**48.6**	**41.1**	**60.0**	**71.2**	**102.4**	**78.9**	**79.1**	**52.1**	**44.8**	**33.2**	**38.2**	**102.4**
	1977	1969	1977	1977	1966	1979	1994	1968	1995	1974	1995	1968	1979
Sinaia 1500	**79.1**	**54.7**	**60.5**	**48.3**	**64.4**	**100.4**	**106**	**64.3**	**118.4**	**94.8**	**75.2**	**74.8**	**118.4**
	1965	1984	2007	1961	2005	2001	1975	1997	2005	1972	1989	1990	2005
Predeal	**43.5**	**44.4**	**96.9**	**33.0**	**84.2**	**122.1**	**106.9**	**87**	**92.1**	**57.9**	**45.6**	**47.8**	**122.1**
	1965	1969	2007	1979	1984	1981	1969	1977	1989	1972	1978	1990	1981
Campina	**53.8**	**68.1**	**94.5**	**39.9**	**73.6**	**112**	**112.1**	**107.5**	**118.4**	**54.3**	**61.7**	**49.8**	**118.4**
	1998	1984	2007	1995	1973	1979	1975	2005	2005	1972	1987	1990	2005
Târgoviște	**40.7**	**37.4**	**48.7**	**44.7**	**137.6**	**119**	**130.3**	**97.4**	**61.9**	**65.8**	**50.4**	**33**	**137.6**
	1996	1968	2007	2004	2005	1979	1975	2005	2005	1972	2003	1969	2005
Ploiești	**48.6**	**22.7**	**32.6**	**43.6**	**75.9**	**102.4**	**92.6**	**91.4**	**121**	**42.1**	**52.3**	**33.6**	**121**
	1996	1981	2007	2005	1997	1979	1975	1997	2005	1998	2004	1974	2005
Slobozia	**32.3**	**37.9**	**39.2**	**33.1**	**49.5**	**62.5**	**47.6**	**61.9**	**60.1**	**62.4**	**32.6**	**40.8**	**62.5**
	1988	1984	1992	1996	1997	1999	1982	1983	1999	2005	1997	1988	1997

**Source: Statistical data from National Meteorology Administration, Bucharest*

The table above shows that at four of the weather stations we have analyzed (Sinaia 1500, Câmpina, Târgovişte and Ploieşti) located in all the three major landforms of the river basin, July 1975 totalized well above-average amounts of rainfall, which actually proved to be the main cause for the devastating flash-floods that followed.

This fact proves the amplitude of the weather phenomena that caused the flash-flood of July 1975 from both a spatial perspective (almost the entire area of the Ialomita river basin was affected by heavy rainfall) and a temporal one (since the storm cells that produced the heavy rain lasted very long, most of them from 24 to 48 hours).

The relatively high humidity contained in the top layer of the soil before the main rain sequence developed also proved to be a very important factor in determining a dangerously rich surface run-off. The phenomenon is intensified by the presence of steep, deforested slopes and also by plowing along the wedge.

3. The methodology used for determining the flash flood potential transmission index in the Ialomița river basin

In order to identify the vulnerable areas subject to processes generated by slope run-off, we have used the Flash Flood Potential Transmission Index (FFPTI) method, first proposed and used by Smith (2003) in the “Western Region Flash Flood Project” (WRFFP) and then by several researchers from Romania, such as G. Minea (2011), M. Mătreață (2011) and M. Borcan (2011).

The main purpose of this method is the estimation of an index that would synthetically express the flash-flood potential for both a major river basin (such as Ialomita River Basin) as well as for a minor river basin (usually sub-components of major river basins).

We have applied the FFPTI method as a case study for the 1-3 July 1975 major flood event that affected almost the entire Ialomita river basin, which thus proves to offer ideal conditions for testing this new methodology.

We have obtained the values of the FFPT index after completing several steps in GIS, as described below:

- The slopes layer was created using the Digital Land Model with a 30 m cell resolution;
- The polygon type thematic layer representing soil texture was converted into a raster type thematic layer with a 30 m cell resolution, as well;
- Using the Corine Land Cover 2006 data set which provides information regarding land use, we have determined the percentage of the entire Ialomita river basin area which is covered by forests and by other classes of land use, thus obtaining a new thematic layer;
- The thematic layers representing the maximum hourly rainfall with a 1%

exceeding possibility and the sum of the hourly rainfall recorded between 1 and 3 July 1975 were added by the kriging interpolation method;

- According to Smith`s classification (2003), in order to determine the vulnerability to flash-flood occurrence we have associated to each value of the above mentioned factors an integer-type value starting from a minimum value of 1 (representing the lowest risk) and increasing to a maximum value of 5 (representing the highest risk). This has been achieved by a re-classification of the four thematic layers;
- By averaging all the factors we have already mentioned we obtain a new final thematic layer which helps us determine the flash-flood occurrence possibility thorough the Ialomita river basin.

4. Outcomes

As a result of the calculations which have been carried out in order to obtain the maximum rainfall with a 1% occurrence probability, GIS helped us to classify the maximum 24-hour rainfall quantities, which were between 92 and 178 mm, into several categories (Fig.1).

We have obtained five classes of values and each class has been assigned a specific indicator, from 1 (lowest risk) to 5 (highest risk).

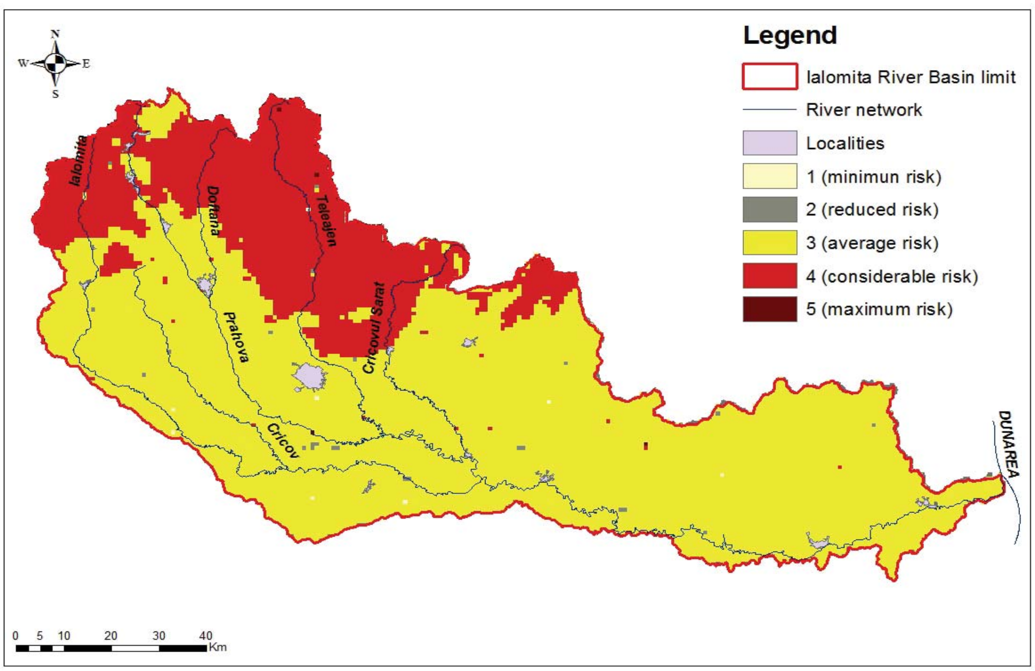

Figure. 1. The classification of the hourly maximum rainfall with a 30 m spatial resolution

Since ***soil texture*** is a main influencing factor of the maximum liquid run-off, we have analyzed it according to the synthetic table "*The adaptation of the hydrological soil groups to the Romanian classification*" (Chendeş, 2007, cited by Mătreață, 2011) and also considered a new soils group, the E group, mainly consisting of clay-containing soils and water-proof soils (Table 2).

According to this table there are five types of soils, considering their texture, so to each class there has been assigned a risk level, from 1 (minimum risk) to 5 (maximum risk).

Table 2. The adaptation of the hydrological groups of soils to the Romanian classification of texture (Chendeş, 2007, cited by Mătreață, 2011)

Group	Texture	Flash Flood Potential Transmission Index
A	Sandy Sandy – sandy loam Sandy – loamy sandy Sandy loam Sandy loam – loam sandy Loam sandy	1
B	Sandy - loamy Sandy loamy - loamy Loamy sandy - loamy Loamy Varied texture	2
C	Sandy loam – loam clayish Sandy loam – clayish loam Loam clayish – clayish Loam – loam clayish	3
D	Loamy – clayish Loam clayish Clayish loam – clayish	4
E	Claysih Areas without infiltration	5

In order to classify ***the slopes and the degree of forest cover***, we have used the five categories already established for the maximum run-off coefficient corresponding to the 1% occurrence possibility rainfall and applicable to small river basins (Miță, 1997).

The correspondence between these five classes of values used for slopes, degree of forest cover as well as for the potential transmission index is found in table 3.

Table 3. The risk categories for slopes, degree of forest cover and flash-flood potential transmission index*

Slopes (°)	Degree of forest cover (%)	Flash-flood potential transmission index
5-10	80-100	1
10-20	60-80	2
20-30	40-60	3
30-40	20-40	4
40-50	5-20	5

** (after Mătreață, 2011)*

By averaging the four elements we have already discussed (maximum hourly rainfall with a 1% exceedance probability, soils texture, slopes and degree of forest cover) we have obtained the thematic layer regarding the flash-flood potential transmission index with a 30 m cell resolution which reflects the influences that the other four elements presented so far have upon surface liquid run-off (Fig. 2).

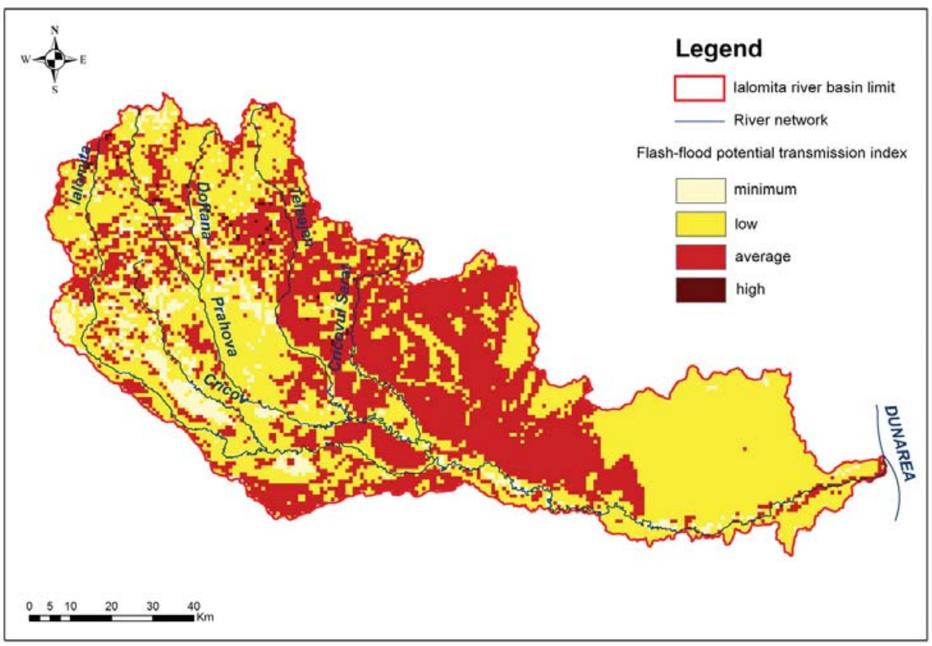

Figure 2. Map of the flash-flood potential transmission index spatial repartition

The data presented in the above figure show that in the Ialomita river basin the low and average risk classes have the greatest share, such territories being less susceptible and moderate susceptible to the occurrence of flash-floods.

The maximum risk areas which are highly vulnerable to flash-flood occurrence are quite scarce, being located mainly in the sub-Carpathian hills, while the minimum risk areas, which can be considered a lot safer from this point of view, are to be found everywhere thorough the river basin.

In order to perform a qualitative check of the values obtained for the flash-flood potential transmission index, we have focused on the 1975 major flash-flood, which affected the entire river basin.

The July 1975 flash-flood in the Ialomita river basin has occurred between the 1st and the 3rd of July. ***The heavy rain*** that had fallen 10 days before the flood event enriched the mass of soil with enough moisture to allow a more abundant surface run-off, which determined the liquid discharges that were recorded at the beginning of the flash-flood to be 1-6 times greater than the normal discharges.

The phenomenon has also been amplified by the ***deforested slopes***, by the ***plowing along the wedge*** as well as by the ***slope's inclination***.

Heavy rains were recorded after July the 3rd as well, more precisely between the 6th and the 8th, triggering even more flash-floods on several small tributaries of the Ialomita river, but with a lower intensity. The map displaying the distribution of the rainfall amounts thorough Ialomita river basin between the 1st and the 3rd of July points out to the fact that the area has been affected by two main rain nuclei (Fig.3).

The first nucleus has developed on the 1st of July, between 3 p.m. and 12 p.m., while ***the second nucleus***, which has been the most intense, has evolved on the 2nd of July between 9 a.m. and 5 p.m. This second rainfall event has been responsible for most of the flash-floods that occurred on the 2nd of July.

The analysis of the spatial distribution of rainfall combined with the thematic layer obtained by overlapping the four thematic layers discussed before (soil texture, slope inclination, degree of forest cover and 1% maximum rainfall) shows that the most vulnerable areas to flash-floods are the ones located in the upper and middle parts of Teleajen river basin and Ghighiu river basin (Fig.4).

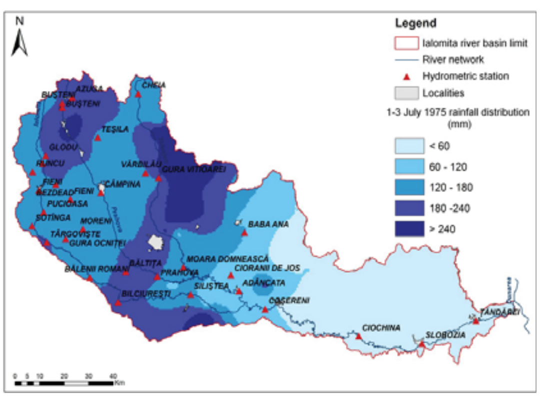

Fig. 3. 1-3 July 1975 rainfall distribution

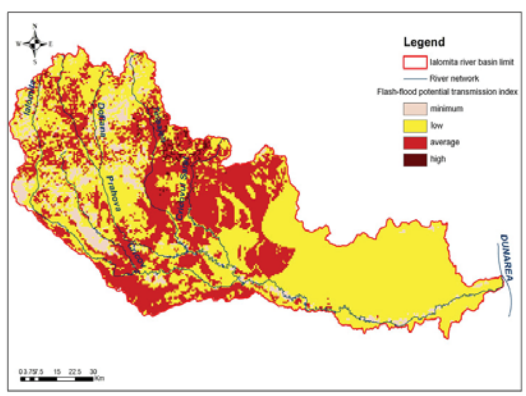

Fig. 4. Flash-flood potential transmission index distribution of the 1-3 July 1975. Ialomița river basin flood event

The analysis of the map regarding the distribution of the flash-flood potential transmission index based on the July 1975 flash-flood points out the fact that the middle parts of the Ialomita and Prahova river basins as well as the upper part of the Prahova basin are covered by ***the average risk class*** and share the greatest ponder.

The lower parts of the Prahova and Ialomița basins develop ***a low risk*** to flash-floods. We can also add here several areas of small size from the mountainous region of the two main river basins already mentioned.

The low risk to flash-floods which has been determined for these regions can be explained by the gentle slopes of the terrain, characteristic to plains, for both inter-fluvial areas as well as for the rivers themselves, while the low risk areas located in the mountains may be explained by the presence of a greater forest cover of the slopes, which inhibit the formation of a rich slope liquid run-off.

The maximum risk covers only small, isolated areas, located mainly in the sub-Carpathian hills region, to the east of the Teleajen river, where severe erosion processes occur and are amplified by the lack of forest vegetation on the slopes of the hills.

The results obtained and presented in the map above have been compared to the real situation on the field, particularly to the maximum discharges that were recorded during the flash-flood of July 1975. These discharges were estimated after waters receded with the help of hydro-topo-metric measurements on the field and were found to have been grater than previous discharges recorded for certain river stations.

The middle parts of Ialomița and Prahova river basins (in which the discharges recorded during the 1975 flash flood were some 40% to 90% grater than previous readings) and also the Teleajen river basin (where flood discharges were 150% to 200% greater than previous readings) are among the areas with an average risk to flash floods.

We would also like to point out the fact that the peak discharges recorded among the middle parts of the Ialomița river basin have been strongly attenuated downstream, towards the lower parts of the basin, in the Cosereni – Slobozia sector, mainly as a consequence of the river bed widening considerably, as well as of the presence of numerous reservoirs located upstream. This enables us to argue that the lower part of the Ialomița river basin is facing a low risk to flash-floods.

5. Conclusions

As a result of the analysis carried so far we can draw the following conclusions:

- The determination of the flash-flood potential transmission index can be achieved using the above presented method for the entire Ialomita river basin as well as for its sub-component river basins;

- In the Ialomita river basin the FFPTI method indicates that the upper part of the basin provides a mitigated surface run-off due to the presence of forests on the mountain slopes, while the sub-Carpathian region faces a severe, torrential run-off which leads to high erosion processes. The plain region also has an attenuated run-off due to the widening of the river bed.
- The validity of this method is confirmed by the case study of the July 1975 flood.

REFERENCES

1. Borcan, Mihaela, Achim, Diana, (2011) *Estimarea potențialului de producere a viiturilor în bazinul hidrografic Ialomița*, Lucrările Conferinței Științifice Anuale ale INHGA, 1-3 Noiembrie 2011
2. Chendeş, V., (2007), *Scurgerea lichidă şi solidă în Subcarpații de la curbură*. Rezumat-Teză de doctorat. Institutul de Geografie. Academia Română.
3. Mătreață, M., Mătreață, Simona (2011), *Metodologie de estimare a potențialului de producere de viituri rapide în bazine în bazine hidrografice mici*, Comunicări de Geografie, Vol. XIV, Editura Universității din Bucureşti, Bucureşti.
4. Minea, G., (2011), *Bazinul hidrografic al râului Putna. Studiu de hidrogeografie*. Rezumat – Teză de doctorat, Universitatea Bucureşti, Facultatea de Geografie.
5. Miță, P., (1997), *Instrucțiuni pentru calculul scurgerii maxime în bazine mici*. INMH, Bucureşti.
6. Mustățea, A., (2005), *Viiturile excepționale pe teritoriul României. Geneză şi efecte*, Tipografia SC Onesta Com Prod 94" SRL, Bucureşti.
7. Smith, G., (2003), *Western region flash flood project*, AMS Conference, Session 6 GIS Applications.
8. Zăvoianu, I., (1978), *Morfometria bazinelor hidrografice*, Editura Academiei Republicii Socialiste România, Bucureşti.