

## **THE PRECIPITATIONS OF THE SUPERIOR BASIN OF THE PRUT AND THE FLOODS OF JULY - AUGUST 2008 IN THE OROFTIANA - STANCA SECTOR. CAUSES, PECULIARITIES AND IMPACT ON THE ENVIRONMENT**

**Dumitru Mihăilă<sup>1</sup>, Diana Bostan<sup>2</sup>, Ion Tanasă<sup>3</sup>, Alin Prisacariu<sup>4</sup>**

**Key words:** abundant precipitations, massive flash flood, material damages.

**Abstract.** In the interval 22-27.VII.2008, in the North-East of Romania and the South-West of Ukraine fell considerable quantities of precipitations after the passage in these areas of a cyclonic formation, well outlined, with a retrograde character and which, at the contact with the highest slopes of the Wooded Carpathians, allowed the precipitation of large amounts of water, which were took over by the Prut and his affluents or other hydrographical arteries. At the entrance in Romania, at Oroftiana, a few days later, the Prut had an impressive flow of flash flood (over 4000m<sup>3</sup>) mainly produced by the precipitations that fell on the Ukrainian territory. The precipitations fallen in the Romanian part of the basin (County of Botosani) or in the Moldavian part (district of Edinet) brought only an insignificant contribution to this flow.

### **Research methods and means**

To analyse the causes, the amplitude and the consequences of the pluviometric episode of 22-27.VII.2008 we used the synoptic situation for the entire Europe (of the archive [www.wetterzentrale.de](http://www.wetterzentrale.de)), the pluviometric maps for the entire territory of Romania for the same interval (source N.A.M.), the pluviometric data of Botosani County (source R.M.C. Moldavia, Iasi) and the levels, flows and volumes measurements of several sections of the Oroftiana-Stânca sector (source D.A. Prut, Iași). We also used several satellite images of the flooded areas at different moments of the analysed interval, a large number of photographic images taken on the field during the flash flood, statistics with

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<sup>1</sup> "Ștefan cel Mare" University, Suceava, România, mihaila\_dum@yahoo.com

<sup>2</sup> Regional Service for Weather Forecast, Bacău, România, srpvbacau@meteoromania.ro

<sup>3</sup> Suceava meteorological station, ion\_tanasa.meteo@yahoo.com

<sup>4</sup> Scholar Group, Darabani, România, prisacariu1985@yahoo.com

material damages taken from the city halls of the communes next to the Prut River, mostly affected by the floods, and also other graphic and cartographic materials. Unfortunately, for the Ukrainian and Moldavian parts, we didn't have pluviometric or hydrometric determinations.

### 1. The localization of the studied valley sector

The Prut springs from the Wooded Carpathians in Ukraine - fig. 1. After it goes on for 248.9km and collects the waters from 8241km<sup>2</sup> it enters our country in Oroftiana and then, on a distance of 704km, till the Danube, it flows forming the North and East border of Romania with Ukraine and Moldavia. From Oroftiana to the river mouth (confluence with the Danube) the basin of the Prut increases its surface with another 20155km<sup>2</sup>.

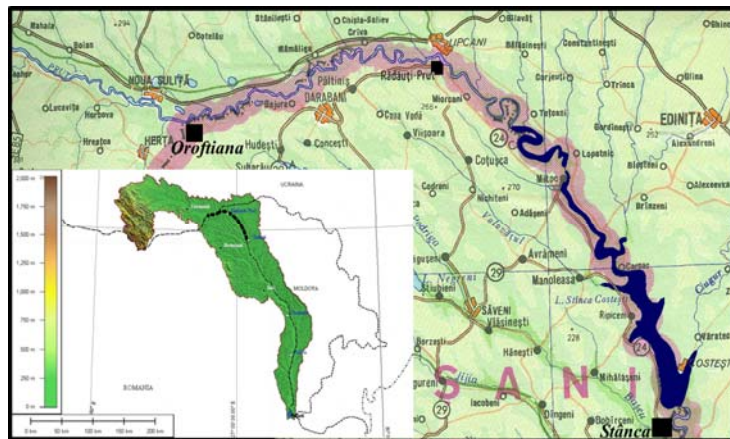


Fig.1. The mathematical and geographical localization of the Oroftiana- Radauti Prut valley sector –as part of hydrographical Prut basin (left - down) and Romania

In the subsequent sector of the valley of the Prut, between Oroftiana and Rădăuți Prut, the valley of this river has an asymmetrical character - fig. 2a and b, with the left side having a very low inclination, due to the fact that it superposes over the long reverses of some cuestas alignments of the Ukrainian and Moldavian territory; the right one, of the Romanian territory, affected on large areas by active or potentially active denudational processes, in quite advanced forms, the torrent and the landfalls being the most representative. The lands between the auxiliary interfluvial top on the right of this valley and the major river bed of the Prut, are in present in an advanced stage of degradation on large areas.

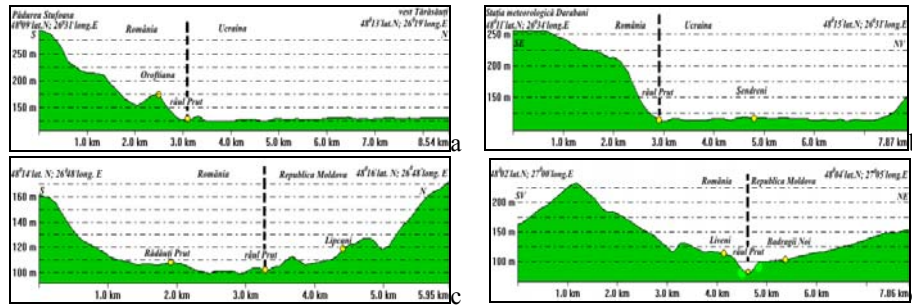


Fig.2 - Transversal geomorphologic profiles through the valley of the Prut in the subsequent sector (Oroftiana -a, Darabani -b) and epigenetic sector (Rădăuți Prut -c, Liveni -d)

In this sector, flash floods and big waters mostly flood the left side of the Prut that doesn't belong to Romania.

Downstream of Rădăuți – Prut, a sector of classic epigeny begins and it surpasses through erosion the stratigraphic gap that exists between Badenian and Cretaceous, descending into rocks more and more resistant to erosion. The valley has a more symmetrical character - fig. 2c and d, the levels raisings over edges affecting equally the Romanian and Moldavian part.

## 2. The synoptic situation in the interval 22-27 July 2008

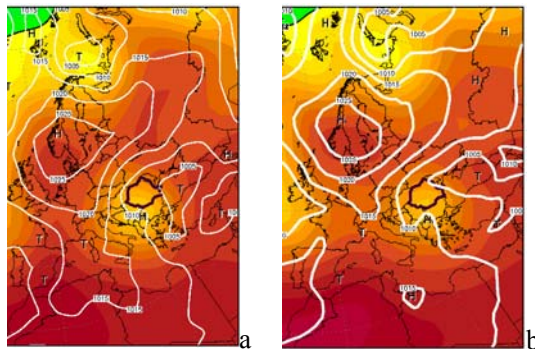


Fig. 3. The distribution of the air pressure at the ground and at the isobaric surface level of 500hPa over the Eastern Europe in 24-25.VII.08 after [www.wetterzentrale.de](http://www.wetterzentrale.de)

The synoptic context that determined the abundant precipitations consisted in a coupling between a nucleus originated from the Arabian Depression and a cold altitude nucleus that persisted a few days and had a retrograde evolution, from the North of the Black Sea to the North of Moldavia and Bukovina. The synoptic and orographic conditions of the mentioned areas produced large quantities of

precipitations over a short period of time, in successive cycles and on vast areas, on one side and on the other of the state border with Ukraine.

Since 22 July 2008, at the ground, on a thalweg of the Arabian Depression a low nucleus of 1005hPa appeared in the basin of the Aegean Sea. In altitude, at 500hPa, a closed nucleus appeared since 23 July with a center over the South of Hungary that evolved gradually over Serbia, the South of Romania, eventually arriving in the West of the Black Sea.

During the next days (fig.3), the pressure continued to decrease, the 1005hPa nucleus extended over the whole basin of the Black Sea, then since 27 July 2008 - fig. 4, it slowly moved over the Sea of Azov through Russia, the territory of our country getting out of his influence.

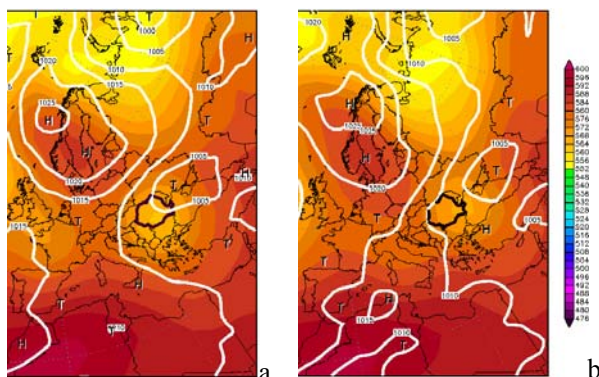


Fig. 4 The distribution of the air pressure at the ground level and at the isobaric surface level of 500hPa over the Eastern Europe in 26-27.VII.08 according to [www.wetterzentrale.de](http://www.wetterzentrale.de)

The nucleus formed in the thalweg of the Arabian Depression - with the afflux of humidity and heat - correlated with the cold of the altitude nucleus that manifested his presence during the four days of the last decade of July (24-27 July 2008) determined the abundant precipitations that led to the record flows registered on the rivers Moldavia, Suceava, Siret and Prut.

### 3. The precipitations fallen in Romania (with a special look over the North-East of the country) in the interval 22-27.VII.2008

In a first stage - 22-23.VII, the precipitations were significant in the West of Romania (not in the North-East - fig.5a), then their area slid slowly to the North-East of the country - 23-24.VII - fig.5b; 24-25.VII- fig. 5c, including at first the mountainous areas and then the ones of plateau, getting together larger quantities, as they were advancing to the North-West of the Suceava Plateau and the Volino-Podolic Plateau, where they reached the maximum quantities.

In the interval 25-26.VII.2008 - fig.5 the precipitations were still abundant; in the interval 26-27.VII.2008 - fig.5e they were significant over some mountain and plateau areas, but since 27.VII.2008 the rains restrained and the precipitations that fell after this date didn't have a significant pluviometric reflex.

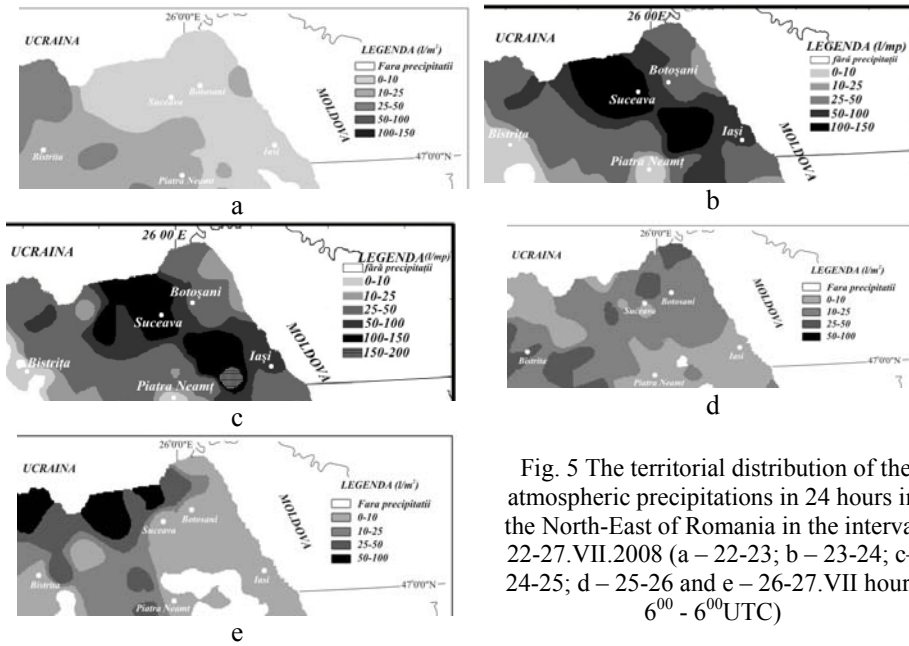


Fig. 5 The territorial distribution of the atmospheric precipitations in 24 hours in the North-East of Romania in the interval 22-27.VII.2008 (a – 22-23; b – 23-24; c – 24-25; d – 25-26 and e – 26-27.VII hours 6<sup>00</sup> - 6<sup>00</sup>UTC)

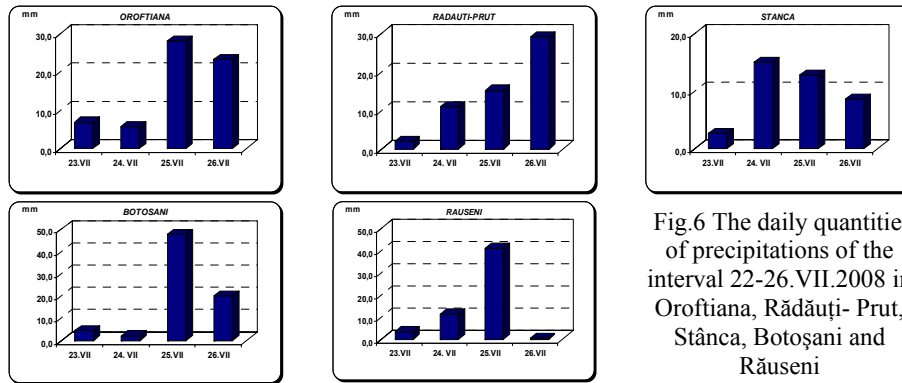


Fig.6 The daily quantities of precipitations of the interval 22-26.VII.2008 in Oroftiana, Rădăuți- Prut, Stânca, Botoșani and Răușeni

It is important that at most points of pluviometric observation of Botoșani County (we selected 5 of them - fig. 6), in the interval with the higher quantities of precipitations (22-27.VII.2008 - very well outlined in the other areas), insignificant quantities of precipitations fell in the East of the county, on the Prut (with daily maximums under 30mm) and a little higher in the Western part of the county (with

maximums in 24 hours under 50mm). In 22 and 27.VII, insignificant precipitations fell in Botoșani County. This aspect argues that the flash flood on the Prut was caused exclusively by the precipitations that fell in the Carpathian area and the Podolian area of Ukraine.

Thus, unlike the hydrometeorologic evolution of the West and the Center of Moldavia, the huge volume of water that caused the tragedies of Baranca and Rădăuți-Prut came from precipitations registered mostly in Ukraine. There are suspicions about the breaking of the dam of at least one accumulation of the Ukrainian territory that could amplify the flash flood wave from the Prut, but this aspect isn't officially confirmed.

#### 4. The hydrological consequences (of the Oroftiana - Stâncă sector) of the abundant precipitations fallen in the Ukrainian sector

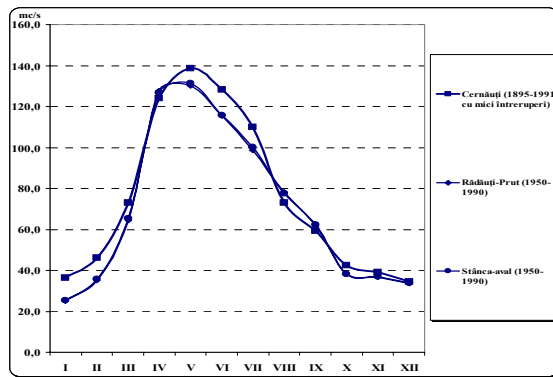


Fig.7 The annual evolution of the average monthly flows at Cernăuți, Rădăuți Prut and Stâncă

During the flash flood of July-August 2008, the flow of the Prut raised to  $4635.0\text{m}^3/\text{s}$  on 28.VII.2008 at Rădăuți Prut and only  $1198.0\text{m}^3/\text{s}$  on 31.VII.2008 at Stâncă - Fig.8. If at Rădăuți Prut the flows evolved outside the antropic intervention, at Stâncă Costești the

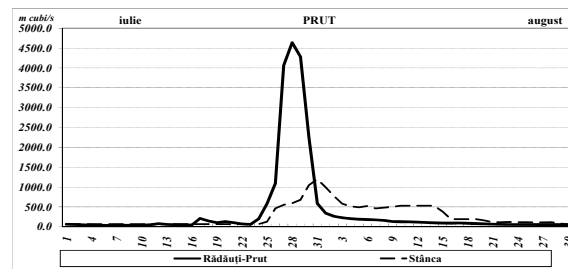


Fig. 8 The flash flood flows evolution from Radauti Prut and Stanca from 1.VII- 31.VIII.2008

In the course of a year, the flows of the Prut have an evolution from January to May, and then an involution from May to January fig. 7. In July, the average flow of the Prut River gets to  $110.0\text{m}^3/\text{s}$  at Cernăuți,  $112.1\text{m}^3/\text{s}$  at Rădăuți Prut and  $100.1\text{m}^3/\text{s}$  at Stâncă. In August the flows of the Prut drop to  $72.9\text{m}^3/\text{s}$  at Cernăuți,  $84.2\text{m}^3/\text{s}$  at Rădăuți and  $77.6\text{m}^3/\text{s}$  at Stâncă.

regularizing role of drainage exercised by the dam of the accumulation lake is also obvious in this flash flood case.

Because we had access only to the level measurements of Cernăuți, Oroftiana and Radauti Prut - fig. 9, we can appreciate the proportion of the flash flood in these three sections, its amplification of Cernăuți and Rădăuți Prut and the fast movement of the flash flood wave from upstream to downstream. In fig. 9, where the time axis is less compressed, we can also see that the flash flood on the Prut (like on the Moldavia, Suceava, Siret etc.) had two peaks, at an interval of two days, more pronounced upstream than downstream, even if they were situated at different quotas (increasing from Cernăuți to Rădăuți).

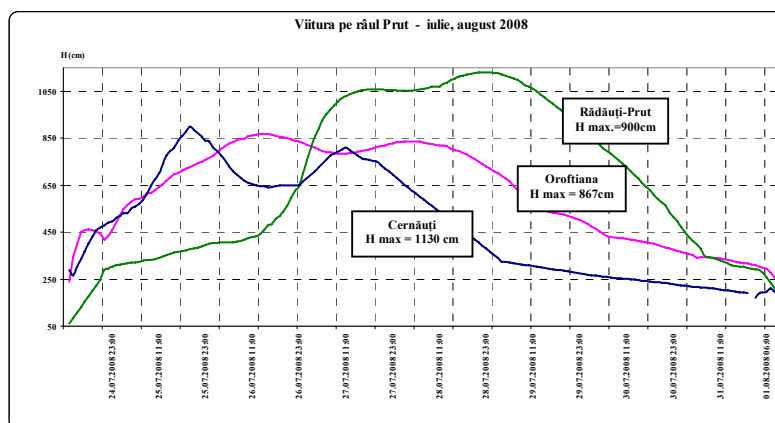


Fig. 9 The evolution of the Prut levels at Cernăuți, Oroftiana and Rădăuți Prut in the interval 24.VII-1.VIII.2008

Comparing only the flash flood of July-August 2008 with the one of August-September 2005 - fig. 10, we can easily see that during the first one, flows were double. Comparing the flash flood of 2008 with the others, we can draw the conclusion that it was the largest since pluviometric observations on the Prut have been made. We can also notice in fig. 10 the flattening of the flows and the decrease of the danger of flash floods with potential of risk downstream of the accumulation lake of Stânca - Costești (for example the hydrometric station Ungheni).

The big volume of water accumulated on the Prut behind the dam of Stanca Costesti (that arrived at 1290.0 mil. m<sup>3</sup> on 31.07.2008 between 3<sup>00</sup>- 6<sup>00</sup>) allowed turbination to reach normal rates again only around 29 August 2008 – fig 11.

During the flash flood of July-August 2008, both the attention rates (CA = 424m<sup>3</sup>/s) and the floods rates (CI = 514m<sup>3</sup>/s) were largely exceeded at Stânca -

Costești. The most affected by the flash flood from July - August 2008 was the Radauti Prut locality (fig. 12).

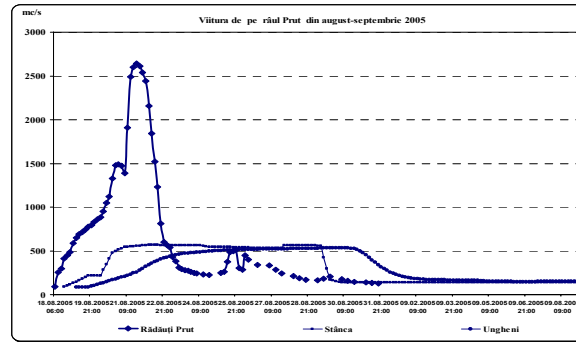


Fig.10 The flash flood flows evolution from Radauti Prut, Stâncă and Ungheni of the interval 18.VIII- 8.IX.2005

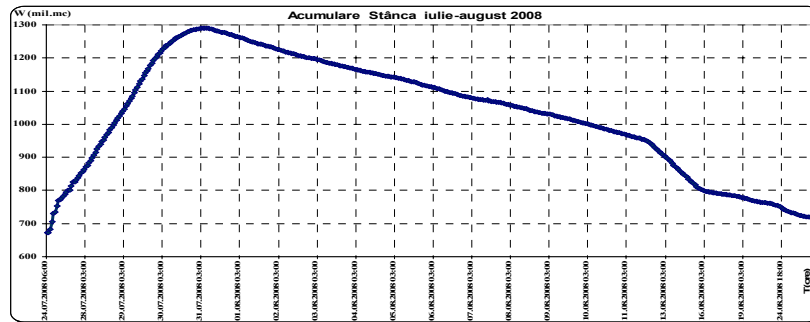


Fig. 11 The evolution of water volume of Stâncă accumulation lake in the interval 24.VII - 24.VIII.2008

The floods of Radauti Prut were caused by the big flow of the Prut and by the geomorphology of the valley and also by the rising of the level in the accumulation lake of Stanca that made the backwater phenomenon propagate upstream on a distance of 70km, up to Radauti Prut. We could say that the management of the turbination and the evacuation of water excess of the accumulation lake of Stanca - Costesti were executed with enough deficiencies and delays during the flash flood.



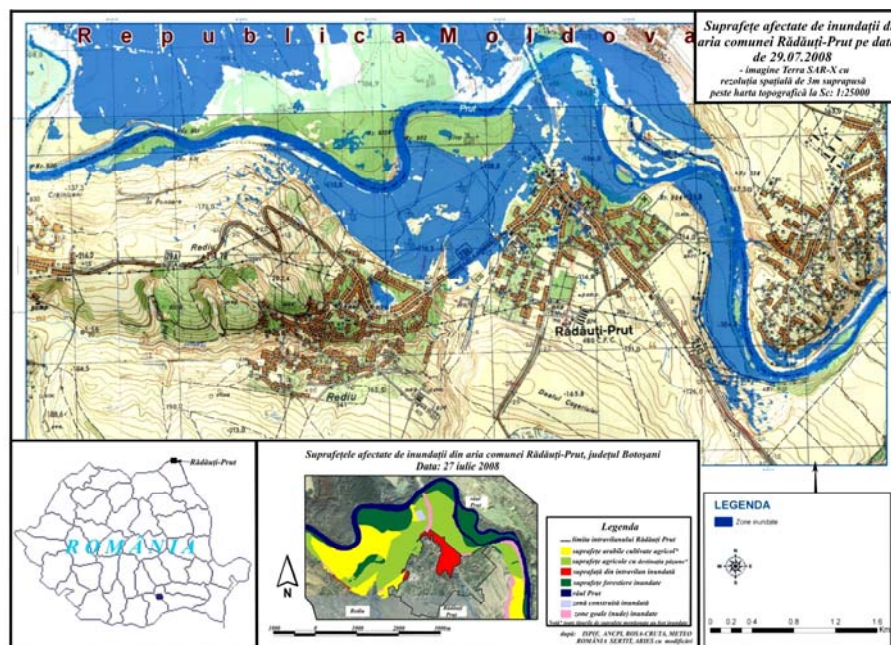


Fig. 12 - The areas covered by water in 27 (down - sketch) and 26.VII.2008 (the topographical map) in Radauti Prut

## 6. The economic and social consequences of the Prut floods

The valley of the Prut in the studied sector is less populated and this is why the damages caused by the floods are not as big as in the other areas. However, the partial statistics of the damages taken of the area city halls indicate the followings:

- the Suharau commune (110ha of flooded pastures and meadows, 40ha arable, 80ha of woods and riverside coppice, 18 flooded fountains, 2.4km of communal roads destroyed);

- the Hudesti commune (56 flooded households, 40 totally destroyed houses, 3 partially damaged houses, 750ha destroyed: 350ha arable, 400 pastures and meadows, 3km of communal roads destroyed, 3 destroyed footbridges);

- the Darabani town (348ha of agricultural area flooded; 298.9ha of forestry area flooded, the water station flooded - fig. 13, which interrupted the water supply for 10 days);

- the Radauti Prut commune (178 damaged houses - fig.16, of which 130



Fig.13 The Teioasa water supply station of Darabani covered by water



Fig. 14 The Prut at Horodistea on 28.VII.2008



Fig.15 National Road 29A Reditu - Radauti (marked by the tops of the trees) under water



Fig. 16 House in Reditu almost collapsing



Fig. 17 The National Road 29A at Reditu



Fig.18 Victims of the disaster at Radauti Prut on 28.VII.2008

demolished, 24 of them 50% damaged and 24 under 50%, 800ha of flooded area, 200 flooded fountains, 15km of county and communal roads destroyed, 300 footbridges destroyed). The victims of the disaster - fig. 18 benefited by the help of the authorities and population, who showed solidarity.

### **7. The impact on the Prut valley's geographical environment induced by the torrential precipitations and by the floods**

Geomorphologically, the right slope of the valley of the Prut between Oroftiana and Radauti Prut suffers ample degradations at every large rain caused by the pluvial denudation, floods reactivation and landfalls. The stream of the Prut deflects to the Romanian shore, especially in the concave part of the meanders, because this is not protected at all. The lakes of the Prut alluvial plain suffer a pronounced process of clogging, decreasing their economic potential year after year. Huge quantities of waste, wood, dry vegetation are taken at every flash flood by the floods and waters and carried downstream, being mostly deposited in the major bed or in the accumulation lake of Stanca.

### **Conclusions and measures**

Between Oroftiana and Stanca - Costesti the Prut is a river that still creates problems, sometimes big, after the intervals with an excess pluviometry. The complex arrangement of the Prut in the Ukrainian sector would limit the negative

impact of the extreme hydrological manifestation of this river. But also the arrangement of the Romanian part of the basin (embankments, uncloggings, planting of forestry curtains) or its exploitation (ballasts, grubbing, usage of the lands) should be adapted to the meteorological and hydrological reality. As long as the shores' protection doesn't exist and the dams are made of faggot (sheaves of wood), which is then strengthened with soil and silts, they won't resist well to the flash flood waves. There is also the problem of the constructions made in the major bed or on the flooding terraces. Both the authorities and the population must understand that even if a flash flood of such proportions would happen only once in 50 years, waters would still wash away all the work they have done in a lifetime.

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