2000 FLOOD – FORECAST AND REALITY IN CRISUL ALB RIVER BASIN

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Abstract: For Romania, as well as for many European countries, the most damaging geophysical events are namely floods and windstorms and in second order also landslides, earthquakes, avalanches and wildfires. In particular, floods produced in several areas of the country cause every year important damages over large areas and also the loss of human lives and economical consequences. In the study area, situated in the Crisul Alb transboundary basin, crossing the Romanian – Hungarian border, many flood events have occurred. These floods have been accompanied by severe inundation events provoked by dike rupture. The most important floods happened in the spring of 2000 when two large floods brought important damages of more than 20 millions US$. These losses included damages to 807 houses, 196 km of roads and railways, 170 bridges, 35 objectives social economic and 84 hydraulic structures, and loss of 134 domestic animals. A flood forecasting system (non-automated hydro-meteorological stations which transmit by phone or radiotelephone) was active. Based upon the information on recorded peak discharges in the upstream section along the Crisul Alb River and his tributaries, a flood forecasting procedure using the method of lag-time corresponding discharges was applied.

Zusammenfassung: Für Romania und viele europäisch Landen, Hochwasser und stűrmisches Wetter sind eine geophisicher Vorfälle von großer Bedeutung. Die Erdrutsch, Erdbeben, Lawine und Blitz sind katastrophal. Die Hochwasser verursachen Verderbens in viele Bereichs, Leute Verluste und economische unvermeidliche Folgen..
Im Studie Bereich aufgestellt im Ca transboundary Bassin, überschwemmt die Kreuzung des rumänischen ungarischen Randes, viele Fälle haveoccured., das diese Fluten acconpanied durch strenge Überschwemmungfälle erregten durch Dikeabbruch gewesen sind. Die wichtigsten Fluten geschahen im Früjahr von 2000, als zwei große Fluten wichtige Beschädigungen von mehr als 20 milions holten. Diese Verluste schlossen Beschädigungen 807 Häuser, 196 Kilometer Straßen und Gleise mit ein. Ein Flutvoraussage System war gegründet nach den Informationen auf notierten Höchstentladungen im aufwärts gerichteten Abschnitt entlang dem Ca Fluß aktives und seine Steuerbaren, ein Flutvoraussage Verfahren, welches die Methode Verlangsamenzeit der entsprechenden Entladungen verwendet, wurden angewendet.

1. Introduction

Romania is a country that suffered quite often flooding, especially in the last decade, when they were more frequent. Practically, there were years when almost during all months occurred flooding, either in small basins, with torrential character, or at zonal or basin scale. These floodings provoked very important damages, that strongly affected the population and different social and economical objectives, and there were registered even losses of human lives. The flooding economical consequences are hard to be supported, in the present context of economical development of Romania.

From the analysis of the rain-flow events that led to flooding over the time, it has been found that the most affected areas by flooding are those situated in the western part of the country because of the climatic and orographic area characteristics. The study zone, Crisul Alb hydrographic basin, is placed in this area.

2. Description of Crisul Alb River basin

The Crisul Alb hydrographic basin (Figure 1) has 4240 km^2. The largest part of the basin is situated in the contact area of four mountainous massifs from Western Carpathians and, by its main course of 234 km length, flows through some tectonic depressions before it reaches Tisa Plain. Crisul Alb springs from the western part of Bihor Mountains, at 980 m altitude, under the Certez peak (1184 m).

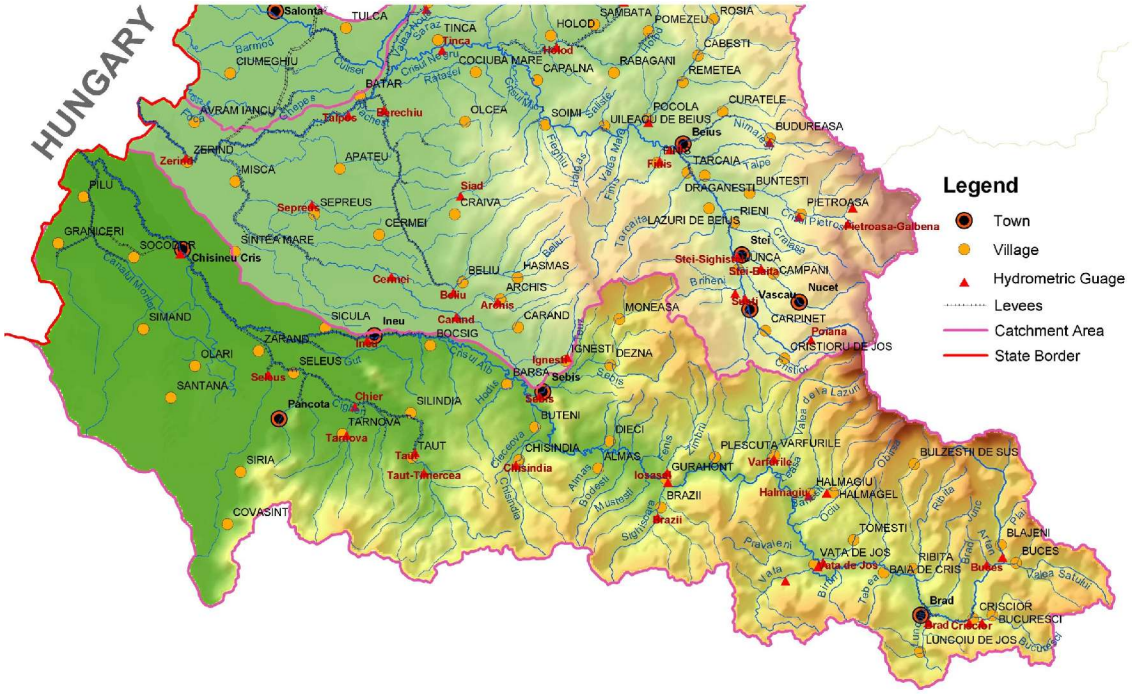

Figure 1. Crisul Alb River basin

The superior course of the Crisul Alb River (till Criscior section), situated in the mountainous area, with only 32 km length and oriented from north to west, is characterized by a cross profile, tipping sharp V. The hydrographic network is relatively dense (the density coefficient is 0.8 – 1.2 km/km^2) and is characterized by important water discharges due to rich precipitation and high velocity of the flow.

The middle course of the river (between Criscior and Cociuba), situated in the hill area, with a bigger length than the superior course (10 km) and oriented from east to west, is characterized by a more balanced longitudinal profile, with smaller medium slopes (approximately 1.2 ‰). This sector is formed by a succession of tectonic depressions in which the river course is meandered because of the reduced slopes divided by narrower gorge with higher slopes and flow velocities. These tectonic depressions represent the areas in which the waters (tributaries) are collected and favor flooding.

The inferior course of the river (upstream of Cociuba village), situated in the plain, with 100 km length and oriented from east to north-west, is characterized by

smaller medium slopes: 0.7 ‰ till Chisinau Cris section and 0.3 ‰ in upstream. In this area, in which the flooding danger is big, there were built dams, in order to protect the agricultural areas. There were also built channels for dewatering and evacuating the excess of water. But some of these buildings are quite old (over 100 years), and are in danger to be damaged, as it was the case of the broken dyke of the Crisul Alb right bank, just in the upstream of the confluence with Cigher, in April 2000.

From climatic point of view, in Crisul Alb basin is characterized by a combination of three influences: Mediterranean, Baltic and Continental, with important precipitation distributed uniformly during the year, with annual medium temperatures that exceed 10°C, with frequent warming air during winter, which determine the snow layer melting that, combined with liquid precipitation, could produce important flooding.

The coefficient of forestation in Crisul Alb hydrographic basin is of approximately 30% from the surface of the entire basin. Due to these values that are quite small it could be stated that this coefficient has is important role in floods occurring.

In the depressions situated along the Crisul Alb River there are many human habitats, very close to the watercourse, in danger to be flooded.

The flooding occurrence in Crisul Alb basin is quite frequent: once per 2-3 years the water level could exceed the flooding critical threshold, and, in the last period, this phenomenon occurred even twice per year. Through the highest floods occurred in this basin could be mentioned those from 1966, 1970, 1974, 1981, 1995, 2000 (in March and April), when the levels exceeded the danger quote.

Hydrometric network existing in the basin of Crisu Alb, consists in approximately 30 hydrometric stations, 6 been situated on the main course. There is a project in progress in the framework stipulates installation of 5 self-monitoring stations which will measure and transmit water level and the hourly precipitations.

3. Hydraulic structures

In order to mitigate the flood effects some structural and non-structural measures have been undertaken. Thus, the considered area is defended by dikes along the Crisul Alb River (Table 1).

Table 1. Dikes

Bank	*Characteristic data*			*Probability*	*Year of construction*
	Length (km)	*Width (m)*	*High (m)*		
Right	66.9	4	5	2%	1877
Left	59.2	2.5 – 4	5	2%	1924

In the same purpose in the study area two reservoirs, one permanent and the other non-permanent, have been build (Table 2).

Table 2. Permanent and non-permanent reservoirs

River	*Reservoir*	*Characteristic data*			*Year of construction*
		Total volume (10^6 m^3)	*Mitigation volume (10^6 m^3)*	*Dam high (m)*	
Cigher	Tauț	33.7	18.5	22	1970
Valea Mare	Chier	-	9.95	4	1973

4. Flood in 2000 year

In condition of a moisture soil, resulted from the waterfall as rain in the period 1-5 April 2000 and a snow pack existed at 1400m altitude, having about 100 cm thickness, had fell precipitations in 6-7 April 2000 period about 30-120mm in the hole basin. Therefore, had produced floods in the hole basin, with a probability of overtake of 2-10%, which generated in the lowest basin at Chisinau Cris a discharge over the assurance 1%.

Flood from 5-7april 2000 was produced by a serial rains which had a maximum nucleus in the interval of 5-6 April. These rains were closed preceded by others fell as far back as 27 February till 5 April that totalized 50mm and which, on one site, contributed to increase the saturation soil degree and on the other site, produced grows of discharges which kept a high level of the river beds. The biggest amount of rain felt in the north part of the flood totalizing over 100 mm (Figure 2).

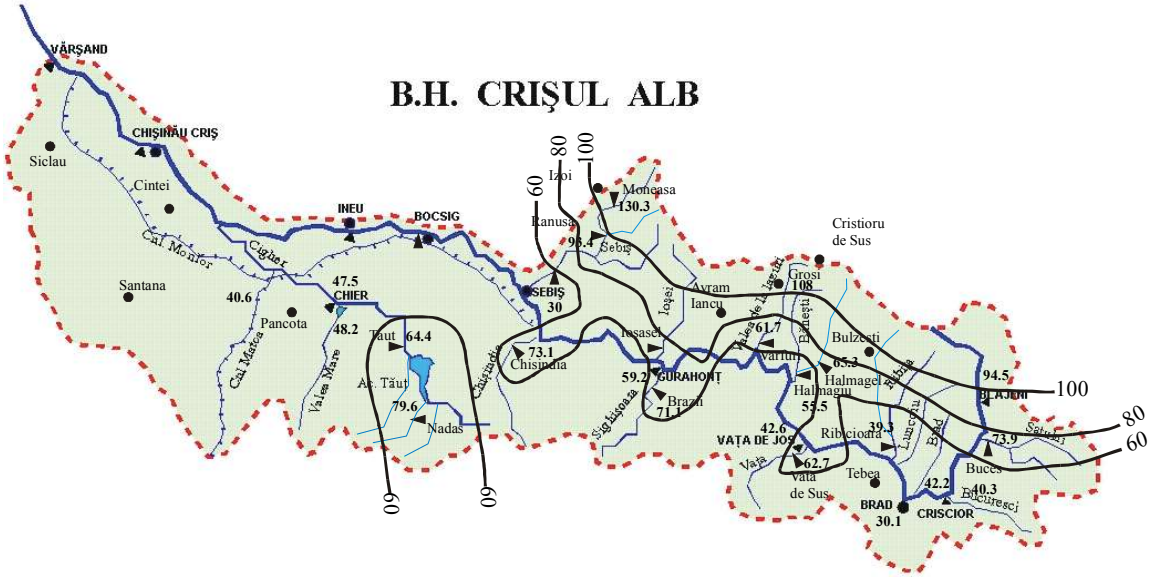

Figure 2. Precipitation in Crisul Alb Basin during 5-6 April 2000

From the analyses of maximum discharges on the main course could be remarked the rare frequency of once per 35-100 years of these exceptional flood occurring on Ineu (Bocsig) – Chisinau Cris river reach. Rare occurring frequencies are also to be noted on Sebis and Crisul Alb rivers at Gurahont. It is remarkable that the flood from the same year in March was higher on the upper stream sector of Crisul Alb river having frequencies of once per 7-100 years (Vata de Jos and Criscior respectively) than in the downstream sector as it happened in April 2000.

Because of maximum discharges registered in downstream of Ineu (values with exceeding probability of 1%) the dikes, projected at 2% assurance, didn't resist anymore in Tipari point. Beginning with 7.04.2000, seven o'clock at Tipari, between 33-36 km on some sectors it occurred the water overflow on the right bank and gradually starting with 12.50 o'clock the dike broke on about 140 m portion (Figure 3) through which flew a volume of about 85 mil m^3 that covered the area between Crisul Alb and Crisul Negru reaching the left dike of Crisul Negru at Zerind.

Figure 3. Dike brake at Tipari

The severe inundation provoked by dike rupture brought important damages of more than USD 20 millions. These losses included damages to 807 houses, 196 km of roads and railways, 170 bridges, 35 objectives social economic and 84 hydraulic structures, and loss of 134 domestic animals (Figures 4 and 5).

Figure 4. Flooded houses

Figure 5. National road between Chisineu Cris and Oradea

The reconstructed discharge after the flood at Ineu - Chisineu Cris, was of 826 m^3/s – a value superior to the discharge with 1% assurance resulted from calculation (Figure 6).

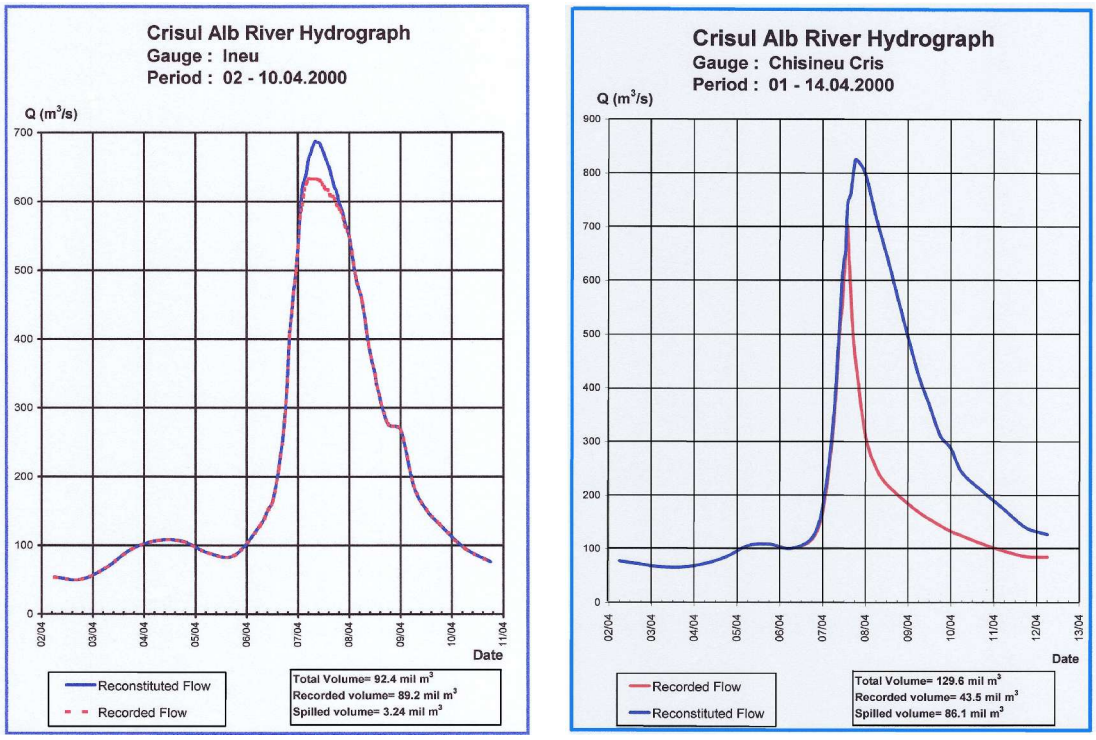

Figure 6. Registered hydrographs in Crisul Alb River basin, at Ineu and Chisineu Cris hydrometric stations

The water was billeted in the frontline area between Crisul Alb and Crisul Negru dikes and the dikes of localization on the Hungarian territory.

For the water evacuation, a mixed Romanian-Hungarian commission decided to effectuate a dike cut on the right bank of Crisul Alb, in the frontline area, on 120 m length. The water evacuation was made with a maximum discharge of 40 m^3/s.

In order to avoid the future damages that could be produced by a similar flood, it was decided to be executed two non-permanent reservoirs on Ineu – Chisineu Cris sector, which would be able to attenuate approximately 12 mil m^3, so that the dykes could be crossed without troubles at floods of assurance of this kind.

5. Hydrological forecast

A flood forecasting system (non-automated hydro-meteorological stations which transmit by phone or radiotelephone) was active. Based upon the information on recorded peak discharges in the upstream section along the Crisul Alb River and his tributaries, a flood forecasting procedure using the method of lag-time corresponding discharges was applied. In Table 3 two examples of the hydrological forecast using the described methodology are given.

Table 3. Hydrological forecast of April 2000 flood

Hydrometric station	*Forecasted peak values*		*Registered peak values*		*Discharge error (%)*
	H (cm) / peak data	*Q (m^3/s)*	*H (cm) / peak data*	*Q (m^3/s)*	
Forecast elaborated in 06.04.2000, 9:30 hours					
Gurahonţ	450/06.04, 22 h	560	442/06.04, 24 h	538	+4%
Ineu	875/07.04, 20 h	622	881/07.04, 9 h	633	-2%
Chisineu Criş	950/08.04, 8 h	704	950/07.04, 14 h	704 826 calculated	0%
Forecast elaborated in 07.04. 2000, 8 hours					
Ineu	900/07.04, 12 h	677	881/07.04, 9 h	633 measured 687 calculated	+6%
Chisineu Criş	950/08.04, 4 h	704	950/07.04, 14 h	704 measured 826 calculated	0%

6. Conclusions

Even using one very simple model for the hydrological forecast the obtained results were good enough.

The deficiencies of the method used for hydrological forecast consist in the fact that, on one hand, the lead-time of the forecast is rather limited and on the other, the tributary input is not properly taken into consideration. That is why an improvement of the forecasting model was necessary and one NATO SfP project started. The project aims to provide to the local and river authorities as well as to other key organizations an efficient and powerful flood-monitoring tool. The tool will significantly contribute to the improvement of the efficiency and effectiveness of the action plans for flood defense.