# SOME ASPECTS OF HYDROLOGICAL RISK MANIFESTATION IN JIJIA BASIN

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**Abstract** – Jijia river basin surface geographically fits in Moldavian Plateau, Plain of Moldavia subunit. Being lowered by 200 to 300 m compared to adjacent subunits, it appears as a depression with altitudes between 270-300 m.
Through its position in the extra-Carpathian region, away from the influence of oceanic air masses, but wide open to the action of air masses of eastern, north-eastern and northern continental origin, Jijia basin receives precipitations which vary according to the average altitude differing from the northern to the southern part of the basin (564 mm in north, 529.4 mm in Iasi). A characteristic phenomenon to the climate is represented by the torrential rains in the hot season, under the form of rain showers with great intensity, fact that influences the drainage of basin rivers. Jijia hydrographic basin is characterized by frequent and sharp variations of flow volumes and levels which lead to floods and flooding throughout the basin. The high waters generally occur between March and June, when approximately 70% of the annual stock is transported. The paper analyzes the main causes and consequences of flooding in the studied area, also identifying some structural and non-structural measures of flood protection applied by authorities in Jijia hydrographic basin. As a case study, the flood recorded in Dorohoi in June 28-29, 2010 is presented.

**Keywords:** Jijia, hydrological risk, watercourses, floods, damages

## 1. HYDROLOGICAL RISK AND HAZARD PHENOMENA

Floods are one of the most disastrous extreme natural phenomena, triggered as a result of direct causal relation between weather factors (precipitations) and the fluid ones. In many situations, to these are added the geomorphic and anthropogenic factors (Bălteanu D., Alexe Rădiţa, 2001; Sorocovschi V., 2002). Flooding occurrence is the result of interaction between precipitations – as a generator factor – and the hydrographic basin, which responds in a specific way to the meteorological impulse, according to its hydrological parameters. Extreme hydro-climatic phenomena are risk factors with a high destructive potential. Between hydrologic and climatic elements there is a dependency, extreme hydrological phenomena being triggered and maintained by the climatic ones. Therefore, floods (the summer ones, specific for the temperate area) are primarily determined by the existence of some rich precipitations with torrential character.

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The remarkable economic development, the expansion of urbanized and deforested territories have induced radical changes in the evolution of extreme hydro-climatic phenomena, the torrential character of precipitations and water flow being determined by the effect of human activities as well.

## 2. JIJIA HYDROGRAPHIC BASIN CHARACTERIZATION

Jijia River crosses the territory of two counties, Botoşani and Iaşi, belonging to two major units of the Moldavian Plateau: the Plateau of Suceava in the west and the Moldavian Plain in the rest of territory (Fig no. 1).

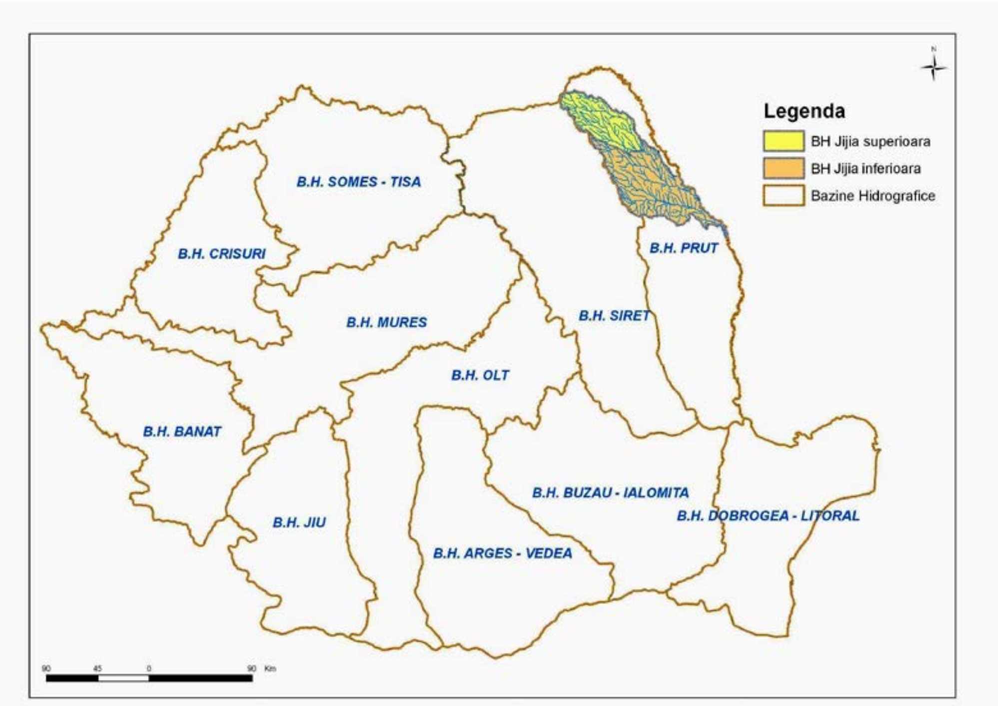


**Fig. 1.** ***The geographical settlement of Jijia hydrographic basin***

Jijia springs at the west of Pomârla locality, on the eastern slope of Bour Massif, it is formed through the merger of waters of two branches, which on a distance of 10 km are well individualized. A branch springs in Ukraine at an altitude of 410 m and after 4 km it enters the Romanian borders, 48°02'48" N latitude and 29°12'39" E longitude. The second river springs from the Bour Massif at 340 m. Here, the slopes are pronounced, 10 degrees, and the longitudinal slope reaches 13 ‰. The sectors are deep, favoring surface flow organization.

After the confluence of the two branches, the formed river is called Jijia, it has a slightly sinuous course, not deepened in some sectors, branched into two arms, with dry lowlands, but floating up to Crişan locality, where the Pomârla brook opens on the left side with the same characteristics. Up to Dorohoi locality vicinity, plain character changes, it being very humid, with reed and even marsh in some sectors, it representing the sink of Dorohoi lezer. Up to Vlădeni the river is a little deep, the major bed being frequently flooded. From this strongly meandering area with deserted river beds, Jijia shifts its valley on the W-E direction up to the entry into the Prut plain, from where on the old bed it flows approximately parallel with it (Băcăuanu, 1992). From the Chipereşti locality, Jijia river route was modified by executing a drain in the Prut river at about 18 km downstream Ungheni.

Jijia river has a basin surface of 5757 $km^2$ and a length of 275 km. The average altitude is 152 m and the longitudinal slope is 1‰. The convolution coefficient for Jijia river is 1.45. Within the basin, Jijia river has a lateral position, ¾ of the drain forming out of the tributaries on the right, which are also the most important.

**Table 1.** ***The characteristics of hydrological regime of Jijia and its main tributaries (based on Arrangement of Prut Hydrographic Basin Plan):***

| No. | River | Hydrometrical Station | The Length of the River (km) | Surface ($km^2$) | Altitude (mdM) | Average multiannual Q (m3/s) |
|---|---|---|---|---|---|---|
| 1. | Jijia | Dorohoi | 267 | 238 | 262 | 0.65 |
| 2. | Jijia | Todireni | 181 | 1070 | 186 | 2.24 |
| 3. | Sitna | Todireni | 3.2 | 940 | 167 | 2.16 |
| 4. | Miletin | Nicolae Bălcescu | 46 | 220 | 202 | 0.469 |
| 5. | Bahlui | Hârlau | 82 | 137 | 317 | 0.438 |
| 6. | Bahlui | Iaşi | 12 | 1717 | 150 | 3.46 |

Jijia river has 36 direct tributaries, out of which 20 are on the left side and 16 on the right (the biggest ones), as shown in Figure No. 2. The main tributaries are: Sitna, Miletin and Bahlui. The Moldavian Plain, through its position in the north-east of the country, is located in an area of interference of northern-western air masses influence with the eastern ones, this fact being evidenced by the presence of a climate with annual average temperatures of 8-9°C, and during winter -20 and -30°C (the low, eastern part being the center of thermal inversions), during summer 18-20°C. The distribution of precipitations in the basin varies depending on the average altitude and it is different from the north to the south of the basin. The multiannual average precipitations vary between 400 and 600 mm per year, there being recorded monthly values depending on the season.

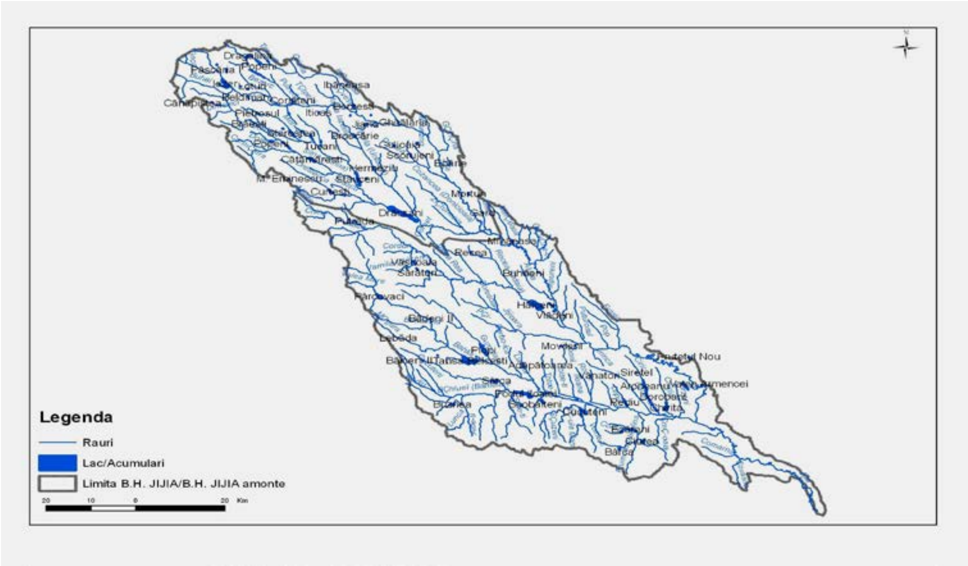


**Fig. 2.** ***The hydrographic network of Jijia basin (GIS databases, Romanian Waters National Administration)***

As a percentage, the greatest quantity of precipitations falls during summer, summing between 35-40% out of the annual total, then during spring 25-30%, during autumn 17-23% and during winter 10-17%. The precipitations fell as snow accumulate, forming a layer of snow whose water reserves supply the rivers during the intervals with positive temperatures. In Jijia basin, the monthly sums of precipitations gradually increase from February to June, when the annual maximal rainfall occurs. From June to February, when the annual minimal rainfall occurs to the majority of rainfall stations and posts, the monthly amount of precipitations gradually diminishes. June, the rainiest month of the year, stands out in being the one with the largest number and the highest frequency of days with different quantity of precipitations. If May sporadically stands out as the annual maximum for the lower thresholds of precipitations amounts daily recorded, in frequent situations (at Dorohoi, Avrămeni, Podu Iloaie) for the superior thresholds for precipitations amounts (≥0,5 mm ÷ ≥30,0 mm), July takes over the annual maximum of days number with large and very large amounts of precipitations. Rarely, August has the annual maximum of days number with different amounts of precipitations (for the days with precipitations of ≥ then 30,00 mm) (Mihăilă, 2006).

In terms of Jijia basin vulnerability depending on summer rains intensity, we observe that the upper basin presents an intermediate vulnerability, and the lower basin a great vulnerability. Along the course, the annual average flow is 10 $m^3/s$ (316 mil $m^3$/year). Spring leakage represents 40-50% of the annual medium leakage, and the winter and autumn ones are reduced to 10-20% of the annual value. The permanent leakage is recorded on major tributaries, on the other rivers, with water gathering surfaces smaller than 50 $km^2$, in reduced leakage period we find a semi-permanent or even temporary character.

## 3. FLOODING IN JIJIA HYDROGRAPHIC BASIN

After analyzing the climatic data from the period 1991-2007, we note that the flooding regime of the region is controlled by the water resulted from snow and ice accumulations melting during spring in some years, and heavy rains during summer in other years. Therefore, most of the floods occurred in the period between late spring and early autumn. Yet, there were a few cases when there was no flooding during summer and the drought persisted beginning with the late spring. Throughout the analyzed period there have been identified 138 major events caused by:

- Flash flooding on the slopes that affect the vulnerable communities;
- Prolonged flooding on the main water courses and confluences, due to the stagnation effect in these lowlands;
- Fast flooding caused by fast leakage and the complex model of terrain.

Concerning the causes that led to flooding in Jijia hydrographic basin between 1991-2007, we noticed that 54 produced through water courses overflows, 42 only through leakage from the slopes and 41 both through water course overflows and leakage from the slopes. Out of the 138 events analyzed in the period mentioned above, 63 occurred on Jijia river and 75 on tributaries. The produced damages are shown in Table No. 2.

**Table 2.** ***Damages produced by watercourse overflows and leakage from the slopes in Jijia basin during 1991-2007 (According to A.B.A. Prut-Barlad)***

| Period | Human Casualties | Social and Economical Objectives (No.) | Individual Households and Annexes (No.) | Arable Lands (ha) |
|---|---|---|---|---|
| 1991-2007 | 14 | 78 | 2969 | 42553 |

In Jijia hydrographic basin there have been applied a series of structural and nonstructural flood protection measures, actions that have been amplified especially due to the historical floods recorded on the surface of the basin in 1969, 1975, 1979.

**Structural measures** Based on the way of action against floods, structural measures are divided into: measures that reduce the maximum (peak) flow of the floods; measures that reduce the maximum levels of river beds; measures that reduce the duration of flood; measures that protect the population and the objectives in the major bed. On the water courses in Jijia hydrographic basin there have been realized the following hydro-technical works: 158 km dams (which protects from floods an area of 32,107 ha), 331 km adjustments, 25 permanent accumulations and 7 perennial accumulations (with a total volume of 588,749 thousand $m^3$).

**Nonstructural measures** These measures contain (Stănescu V. et.al., 2002):

Land planning and management; major bed zoning and management; risk maps elaboration; developing in floodable areas discouragement; specifying the restrictions on building permits.

Hydrologic warnings and forecasts concerning the floods, which are based on realization and development of operational hydro-meteorological informational systems.

The exploitation of defensive hydrotechnical works against floods, reconsidered on the basis of flood forecasting information.

Adequately agricultural land usage planning for retaining the water in the soil.

## 4. CASE STUDY THE FLOOD RECORDED AT DOROHOI IN JUNE 28-29, 2010

Due to rainfalls, Jijia river reached the flood quota at the hydrometric station Dorohoi at the very beginning of 23.06.2010, then during the following night at 22:00 o’clock it overcame by 28 cm the flooding quota, Jijia reaching thus a Hmax = 488 cm and a flow of 35.9 $m^3/s$. Although the state of alert was permanently maintained, the flooding quota was reached again only in the evening of 28.06.2010 (on 28.06.2010 at 18:00 o’clock it was recorded H = 460 cm). However, in only 5 hours, Jijia recorded a maximum level of 874 cm (with 274 cm over the danger quota level) and a flow of 190 $m^3/s$ *(Fig no. 3).* In fact, the large amounts of precipitations fallen in the basin peak on the tributaries formed a fast flood on Buhai brook, which combined with the one on Pârâul Întors brought a share of water that could not be entirely taken over by Jijia river bed. Thus, the whirling waters passed over the bridge on Mihai Viteazu Street, rapidly advancing down the street capturing lots of people in their houses. The small section of drainage (due to undersized bridges and gathered floaters) led to the flooding of the low area in Dorohoi city and provoked the accumulation of a water volume downstream Ezer accumulation *(Fig no. 4).* Beginning with 29.06.2010, 01:00 o’clock, the water level in the artificially created accumulation upstream the dam body exceeded the spillway stage I of the high waters tipper (153.00 mdMN) and there occurred the discharge from downstream to upstream over the spillway ridge until 01.07.2010 – 12:00 o’clock.

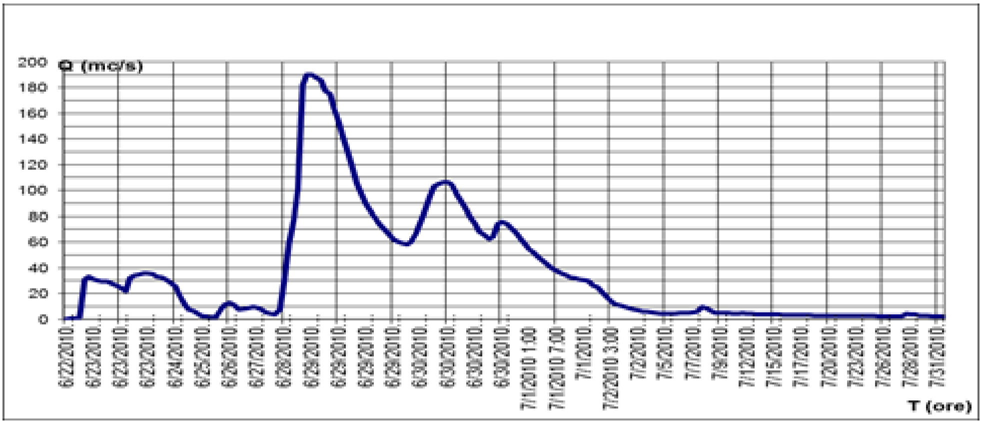


**Fig. 3.** ***Jijia river flood at Dorohoi June-July 2010 (According to A.B.A. Prut–Bârlad)***


**Fig. 4.** ***Orthophotomap Dorohoi municipality***

The maximum height of spilling blade was 93 cm above the spillway stage I of the high waters tipper (153.00 mdMN) and 43 cm above the spillway stage II of the high waters tipper (153.50 mdMN).As a consequence of the produced flood, 6 persons from Dorohoi municipality lost their lives, 53 houses were completely destroyed and other 427 buildings remained at risk of collapse.

## 5. CONCLUSIONS

Jijia hydrographic basin is an area where the hydrological risk exists and manifests both along Jijia River and its tributaries. The geographical position of the river, but also the torrential rains determined by the cyclonic activity specific create favorable conditions for triggering hydrological risks. On the small tributaries, especially on those with a semi-permanent character, the torrential rains produce very large flows, which often cannot be taken over by the minor beds, while in floodable low plains on the main course the effect of torrential rains sensitively decreases, the determinant role in the formation of maximum flows belonging to lasting rains, or snow melting combined with a rainy period.

The communities established along the tributaries with a greater drain slope are the most exposed to fast floods, while the low floodable plains are exposed to prolonged flooding.

The climate changes, chaotic developments, without taking into account the floodable areas and also the increased erosion lead to an increase of economic and social vulnerability concerning the flooding risk.

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