Risks associated with rainfall and floods in the Moldavian Plain

Dan BURUIANĂ[1,2*], Liviu APOSTOL[1] and Dana MACHIDON[1]
[1] Al. I. Cuza" University of Iaşi, Faculty of Geography and Geology, Iaşi, Romania
[2] Water Resources Administration - Prut-Barlad Rivers, Romania

* Correspondence to: Dan Buruiană, Al. I. Cuza" University of Iaşi, Faculty of Geography and Geology. E-mail: dan_buruiana@yahoo.com.

doi: 10.4316/GEOREVIEW.2014.24.1.166

GEOREVIEW

Article history
Received: March 2014
Received in revised form: August 2014
Accepted: September 2014
Available online: October 2014

ABSTRACT: Climate changes, less effective land exploitation and insufficient security infrastructure against extreme phenomena induce vulnerabilities for the Moldavian Plain, where floods are relatively frequent. The middle and lower segments of the major streams dispose of improved hydro-technical infrastructure to prevent floods, still, the secondary streams and tributaries, with pronounced torrential character remain vulnerable. The torrential character of the majority of rivers in the Moldavian Plain results in management difficulties related with risks at maximum flow, especially on the first rank tributaries. Our study analyzes the main causes and consequences of floods in the Moldavian Plain and identifies potentially significant flood risks areas.

KEY WORDS: Moldavian Plain, floods, hydrological risks, vulnerabilities

1. Introduction

The torrential character of the most rivers in the Moldavian Plain accounts for management difficulties of the risks associated to maximum flow, especially on the first rank tributaries. The main stream that crosses the Moldavian Plain, Jijia, displays numerous accretions put in place between 1960 -1990, the most developed system in this sense and including tens of kilometres of embankments along settlements. Nontheless, the risk posed by maximum leakage from the hillsides confining Jijia mainstream is still high. Even if floods represent normal natural phenomena which are characterized by repeatability, human and material losses become some undesired drawbacks.

1.1. Terminology and methodological issues on the study of risk phenomena

The non-periodic variability of climate at global scale related to air masses movement from different origins (tropical, polar, Atlantic) generates climatic hazards and risks with manifestations and consequences that deprive people of life's necessary resources and accumulated goods. Extreme natural phenomena like earthquakes, volcanic eruptions, fires, droughts associated with climatic risks tend to commute the development of human society, civilization and economy

inducing vulnerabilities, presently seen as more frequent in relation with human casualties and material losses (Bogdan and Niculescu, 1999).

2. Characterization of the study area

The Moldavian Plain, also called the Hilly Jijia Plain is a physical - geographical subunit of the Moldavian Plateau. Located in the north-eastern part of the country it is drained, mainly by five rivers: Ghireni, Volovat, Başeu, Corogea and Jijia (fig. 1).

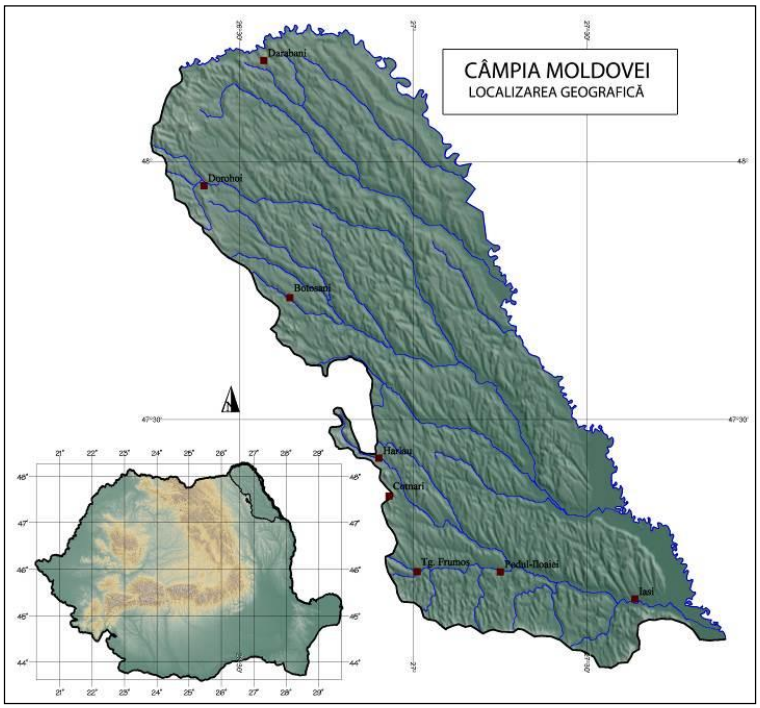

Figure 1. The Moldavian Plain - geographical location and relief.

The Corogea, Volovat and Ghireni rivers carry out their supply basin entirely within the Moldavian Plains and the Başeu river displays 10% of its upper basin in the Suceava Plateau. The Jijia river drains, on approximately 80% the middle, the western and the southern parts of the Moldavian Plain and on 20% the Suceava high Hills, in the eastern part of Suceava Plateau and in the northern Central Moldavian Plateau (Pantazica, 1974).

Form the hydrographic point of view all the rivers taken into consideration are situated on the right banc of Prut river and developed within the eastern part of the Moldavian Plateau. To the west and south, the study area is bordered by the Siret river, and the high hills of Bour, Hapai, Bucecea, Dealul Mare, Strunga, Trei Parale, Toader, Mogoşeşti, Repedea and Paun. The southern and the eastern part is bordered by the Prut River, the main hydrographic stream that collects all the rivers to drain the North-Eastern Moldova.

The geographical features of the region gradually influence the hydrological regime. The positioning in the North-Eastern of Romania imposes that the Atlantic and Mediterranean influences become more attenuated with increased continental climatic regime influences form the. The accumulation of water reserves and their variation in space and time are influenced by the specific geographical factors in the Moldavian Plain, in their complexity and the dimensional elements of the river and their supply basins display, their own peculiarities compared to other

Romanian relief units and subunits (Suceava Plateau, Central Moldavian Plateau, the sub-Carpathian units).

Among the important factors we distinguish in relation with flood episodes there is the climate, through its components (temperature, precipitations, humidity and the dynamics of air masses etc.) as natural conditions with direct influence over the studied phenomena. The type of precipitation, within the river basins, determines the types of water supply and the amount of precipitations affecting the volume of fluid leaks. Additionally, the air and water temperature regime affect the development of various ice formations in winter. Low air humidity and the dynamics of the air masses intensify water consumption and increases evapotranspiration. There is also an uneven distribution of rainfall during the year which in correlation and changing intensity of snow melting which influence the flow regime and the solid part transportation.

2.1. Spatial distribution of rainfall and heavy rainfalls

Rainfalls, as climatic elements, influence and are influenced by the specifics of a certain geographical unit and its landscape features as an assembly. The large spatial and temporal variability of rainfalls induce significant changes in the social and human activities through their impact on agriculture, transportation, tourism, constructions and other activities (Mihaila, 2002).

The analysis of rainfall spatial distribution includes data from the observations on rainfall in 1981-2011 interval at 37 meteorological stations and pluviometric stations (nine weather stations and 28 pluviometric stations), located within the Moldavian Plain and its vicinities (fig. 2).

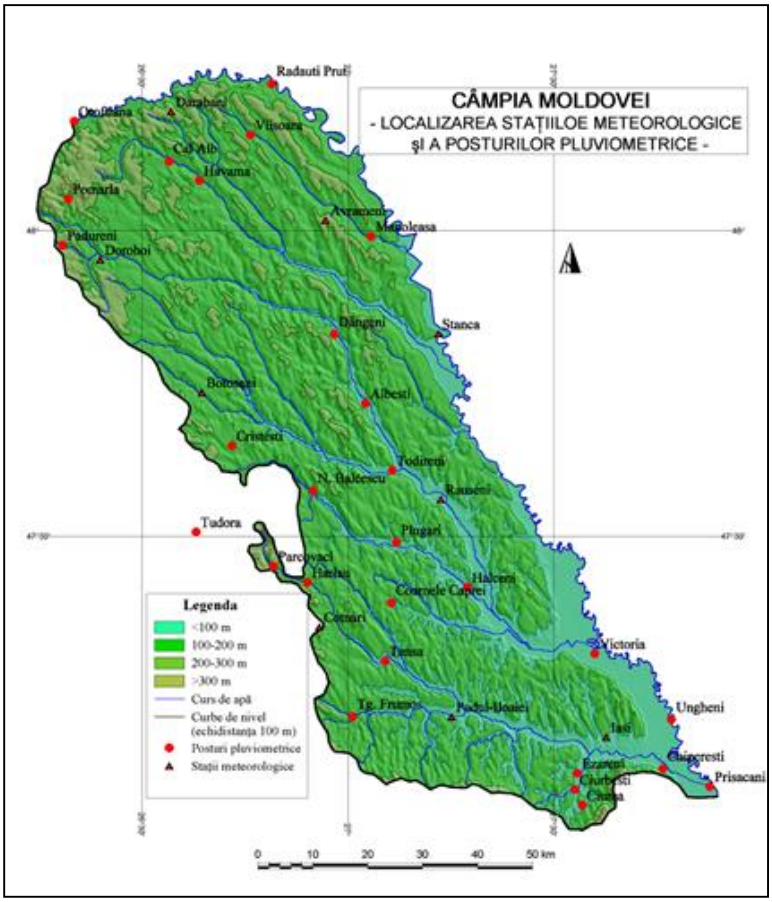

Figure 2. The Moldavian Plain - meteorological and the pluviometric stations.

Spatial distribution of the pluviometric stations and the weather stations are analyzed within a regular network of regular points (including posts at the limit of the study area), in order to map out the spatial distribution of the annual average precipitations.

The analysis of the annual quantities of rainfall distribution map in the Moldavian Plain reveals that the atmospheric precipitations decrease from west to east due to the decrease in altitude in this direction with increased frequency of humid air masses in the western part, as air masses originating from the Atlantic. The Foehn air masses down-sloping from the western high hills do not impose in the rainfall regime, to the east, according to the rain gauges vertical form in the Moldavian Plateau.

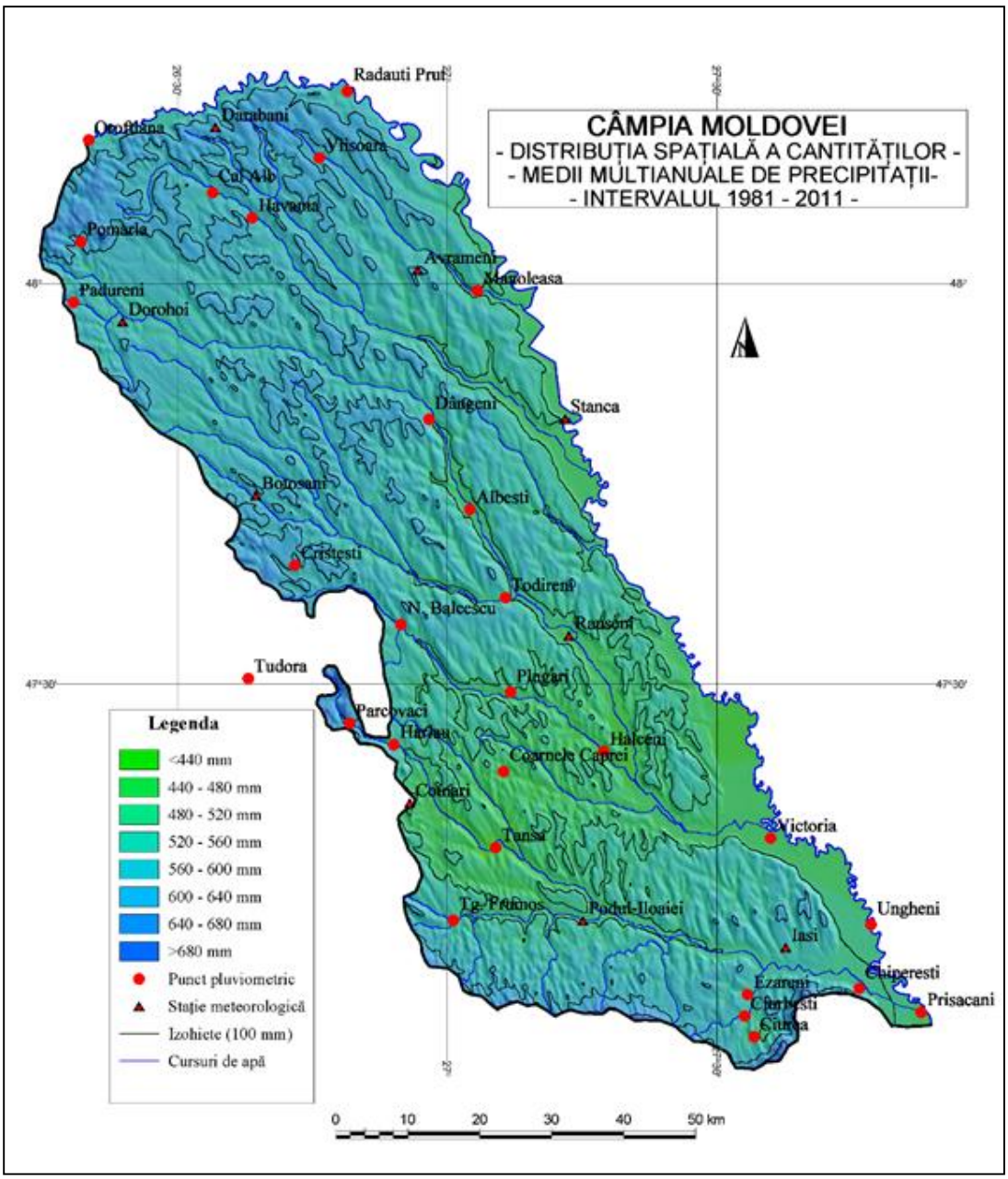

Figure 3. The Moldavian Plain - meteorological and the pluviometric stations.

The map shown in Figure 3 points out the following:

I. The areas with higher altitudes inside the general landscape benefit of increased precipitations (Ibăneşti Hill in the north: Pomârla - 623.9 mm Copalau - Cozancea - Guranda Hills, in the middle: Cristeşti - 585.3 mm, Nicolae Bălcescu - 564.8 mm). In this respect, the lower Bahlui catchment area deserves a special attention. The Coast of Iasi, a barrier of 350 m to the northwest, generates higher amounts of rainfall in the lower Bahlui basin (were the ascent of air massestakes place), (see also Jijia valley to the north of Iaşi, Victoria, 467 mm).

II. The lower altitude areas are also the areas with the lowest annual amounts of rainfall. Among them we can mention, in the North - Eastern part of Upper Jijia Plain: ac. Cal Alb 456 mm; Stanca, 459 mm and in the south - west, downhill of Dealul Mare - Hârlău (Tansa, 467.20 mm Coarnele Caprei, 473 mm). A third area, with lower rainfalls stretches along the Prut River valley.

III. In addition to the pluviometrical differences outlined above, there is also an alternation of wet sectors overlapping on the areas with higher relief and also dry sectors superposed in the lower zones. The succession is more clearly highlighted to the north and west and to the south and east areas. The slopes exposed to humidity advection via air masses from the north - west have increased precipitations, at general level and the slopes exposed to drier air masses from the south – east register decreased precipitations. Both types of air masses suffer from föehnization processes and larger differences appear on the slopes exposed to advection of maritime air masses (Apostol, 2013).

Heavy rains are atmospheric phenomena with short term high-intensity influence on the environment, specifically manifested via erosion and floods. They are characterized by large amounts of rainfall in short intervals and sudden change in the intensity of rain, with episodes of high and low intensity and increasing duration.

Heavy precipitation has an increased impact on both physical-geographical processes and the technical work. All the aspects to emphasize torrential rains are taken into account when fall of a large amount of liquid in a short period of time. The increasing amount of water per unit area, accompanied by the growth in duration of rain episodes generates large quantities also at lower intensities.

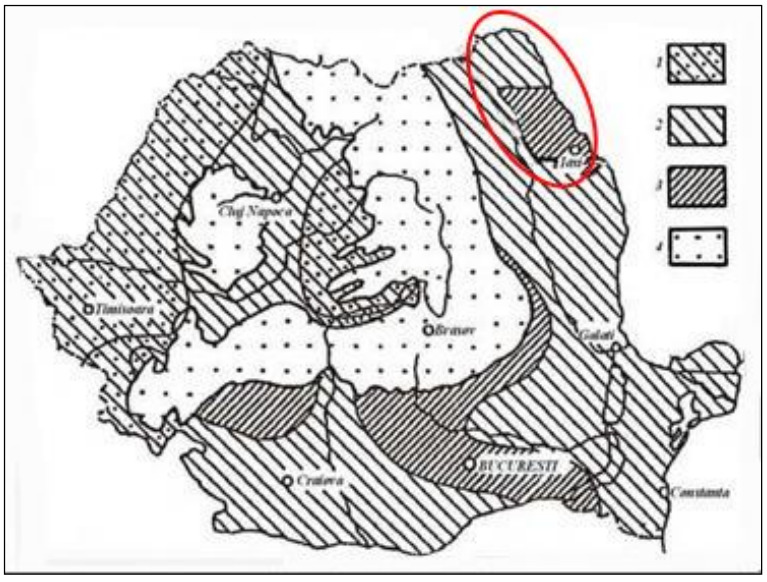

Figure 4. The vulnerability of Romania and Moldavian Plain do to the torrential rain (1 - low, 2 - intermediate, 3 - high, 4 - Combined) - by Octavia Bogdan et al., 1999.

Regarding the vulnerability of Moldova Plain in relation to the summer rainfall intensities, we observed that the Northern half of the plain displays an intermediate vulnerability and the

Southern half displays a higher vulnerability. We also note that the entire space from the east, south-east and south of the Carpathians Range is vulnerable to an appreciable extent as a consequence of heavy rains with medium or large intensity.

Referring to fig. 4 we can conclude that the areas with predominant oceanic influence have lower frequencies of torrential rain compared to the Moldavian Plain. At general scale the degree of vulnerability induced by the intensity of summer rains increase from WNW to SSE.

3. Flooding in the Moldavian Plain

The analysis of climatic data for the 1981-2011 interval shows that the flood regime of the region is controlled by the melting snow and ice melting snow and ice accumulated in the springtime in the last years, and in some years by the heavy rains in the summertime. Therefore most floods occur in the late spring and early fall interval. However there are few cases with no floods in the summer and persistent droughts across the entire late spring to fall interval. The analysis of flood records for the last twenty years reveals 156 major events caused by:

- flash floods on the slopes affecting vulnerable communities;
- prolonged flooding on main rivers at the confluence due to the effect of temporary ponds in certain depressions;
- flash flooding due to rapid leakage and complex terrain model on sparsely vegetated areas.

As far as the causes of floods in the Moldavian Plain are concerned, in the 1991-2011 period, 68 are the result of river overflows, 55 represent water discharge from the slopes and 33 are overflows of water courses combined with water discharges from the slopes. The events concerning the Prut River and the losses accumulated in the 20 years interval are quantified in the Table 1.

Table 1. Losses caused by river floods and discharge on the slopes in the Moldavian Plain during 1991-2011 period (according Prut-Barlad ABA)

Period	Human casualties	Social, economic (pcs)	Individual households and annexes (pcs)
1991-2011	22	126	3468

3.1. Flood risk assessment

Based on the accumulated the information the study proceeds with the preliminary assessment of flood risks in the Moldavian Plain and an identification of areas with potential significant risks caused by flooding. Such preliminary flood risk rating involves identifying significant historic floods that have had significant consequences: human activities, environment, cultural heritage and economic activity, and delimitation of areas with significant potential flood risks, in other words the floods forecasted areas for the Moldavian Plain. The forecast assumes the following three steps:

1. Collecting information on historical floods (in the past), the identification and selection of significant events of historical events based on the criteria proposed by INHGA;
2. Mapping sites of historical floods (GIS)
3. Identify areas with significant potential flood risk based on available data and project the results for spatial distribution in GIS.

Table 2. Summary of significant historical events (according to INHGA)

Name/Flooded location	Event start date	Duration of event (km²)	Flooded area (km2)	Length of flooded river sector (km)	Frequency
r. Prut - av. loc. Oroftiana am. ac. Stânca	2008-07-24	8	51.830		0.1%
r. Prut - av. loc. Oroftiana am. ac. Stânca	2010-06-21	20	36.543		0.7%
r. Prut - av. loc. Zaboloteni	2010-06-21	60		337.250	10 %
r. Jijia - sector loc. Hilişeu-Crişan Dorohoi	2008-07-24	4		25.873	10%
r. Jijia - sector loc. Hilişeu-Crişan Dorohoi	2010-06-21	7		25.873	10%
r. Jijia - av. loc. Rediu şi afl. Miletin, Jijioara	2008-07-24	4		213.357	10%
r. Buhai - av. loc. Pădureni şi afl. Pârâul Întors. - av. loc Văculeşti	2010-06-21	3	8.046		1%
r. Bahlui - av. loc. Pârcovaci	2008-07-24	5		104.384	10%
r. Bahlui - av. loc. Pârcovaci am. confl. Băhlueţ	2010-06-21	7		60.657	10%
r. Băhlueţ - av. confl. Păşcănia	2008-07-24	3		36.576	10%
r. Băhlueţ - av. confl. Păşcănia	2010-06-21	7		36.576	10%
loc. Cucuteni - r. Cucuteni	2008-07-24	3		0.986	10%
loc. Brăeşti - r. Albeşti	2008-07-24	3		1.548	10%

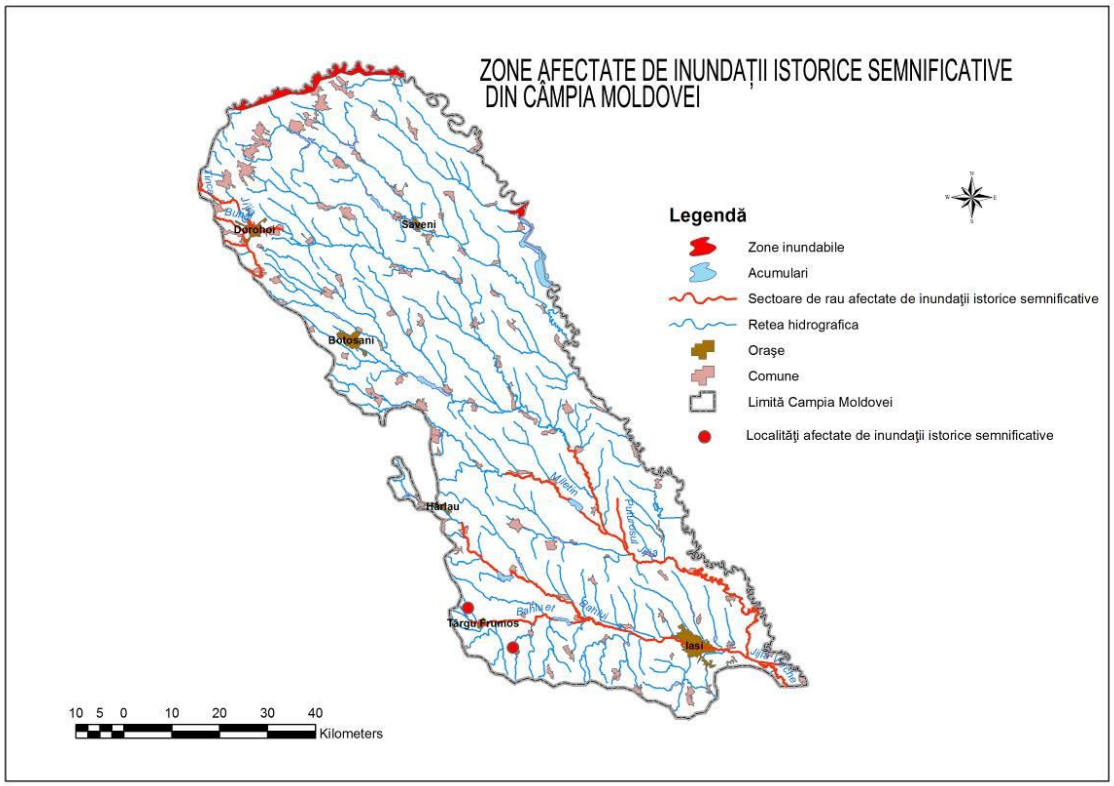

Figure 5. Significant historical events identified in Moldavian Plain (according to INHGA).

Identification and selection of significant historical floods are considered both as hydrologic criteria (to identify significant floods, in terms of probability) and as magnitude of the effects (criteria for the identification of significant historical floods in terms of losses). The selection of historically significant areas affected by floods is based on the analysis of the following aspects:

- information available about the losses in the towns where the selection criterion is the number of affected households per village (minimum 10); considering that there are many places affected by the event, the criterion is in conjunction with other associated losses (flooding a socio-economic objective - school, hospital and, or roads, important land areas or valuable cultural objectives);
- maximum number of recorded flow rates (maximum flow criterion products> Qmax10%); where in unmonitored hydrological river sectors, the probability significant events is estimated based on the experience of ANAR specialists.

Based on the above mentioned criteria there are 13 significant historical events mentioned in Table in 2 and illustrated in Figure 5.

In determining the areas with potentially significant flood risks in the Moldavian Plain, the INHGA is applied, as follows:

- potential flood areas with reported extreme historical floods;
- assessment of the potential impact at floods (consequences).

The components taken into account to assess the losses are: population, roads and railways, bridges, work adjustment, buildings, agricultural areas.

Figure 6 and table 3 and present the potential flood risk areas in plains of Moldova.

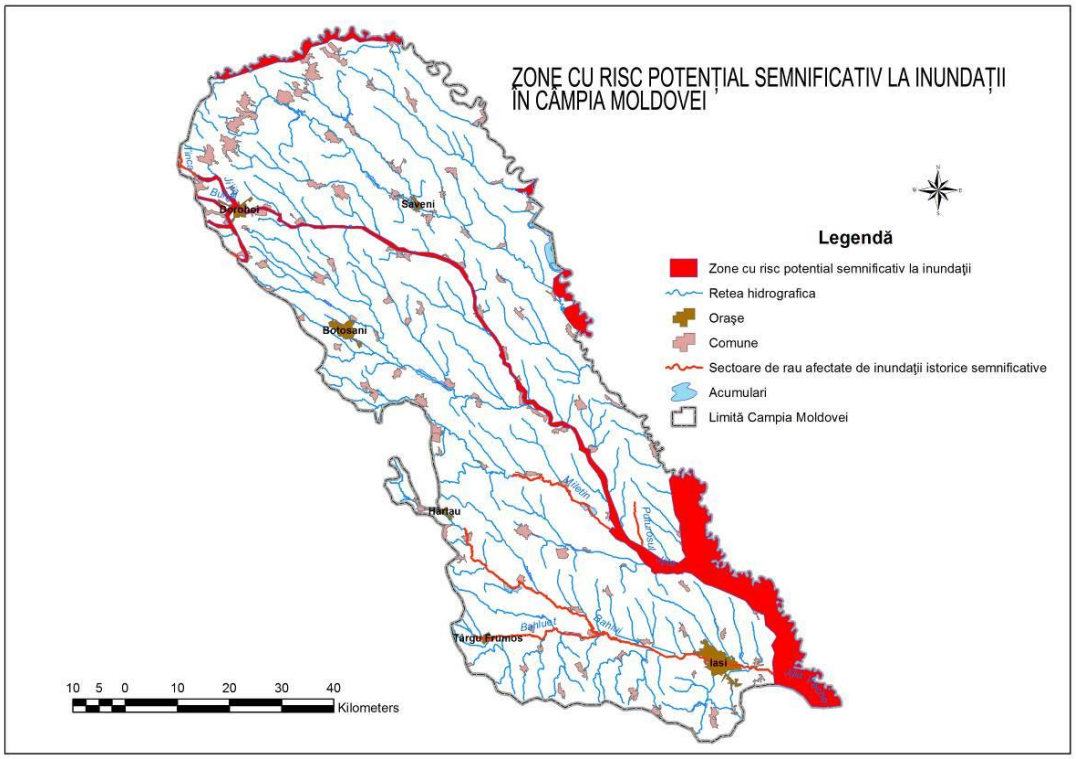

Figure 6. Areas with significant potential flood risk in the Moldavian Plain (according to INHGA).

Table 3. Summary of significant historical events (according to INHGA)

Nr. crt.	The area of potentially significant flood risk
1	r. Prut - sect. av. loc. Oroftiana am. loc. Miorcani
2	r. Prut - av. loc. Crasnaleuca am. loc. Cucuneştii Vechi
3	r. Prut - sector av. loc. Stânca am. loc. Româneşti
4	r. Prut - av. loc. Zaboloteni
5	r. Jijia - sect. av. confl. Pârâul lui Martin am. cfl. Jirinca
6	r. Buhai - av. Pădureni şi afl. Pârâul Întors av. Văculeşti
7	r. Miletin - av. confl. Valea Rea
8	r. Bahlui - av. loc. Pârcovaci am. confl. Băhluet
9	r. Bahlui - av. loc. Pârcovaci
10	r. Băhlueţ - av. confl. Păşcănia
11	r. Cucuteni - av. loc. Cucuteni
12	r. Albeşti - av. loc. Brăeşti

4. Conclusions

The Moldavian Plain region is characterized by hydrological risk that occurs and manifest on the main courses and their tributaries. Location of torrential rains caused by cyclone activity creates favorable conditions that trigger significant hydrological risks. Small tributaries, especially those with semi-permanent character suffer from torrential rain and result in extremely large flows that often cannot be drain in the riverbeds. In flat-land areas floods are not controlled by torrential events in the decisive manner as far as the maximum flow is concerned as a consequence of long-term rainfall or snowmelt superimposed on a rainy period.

- Communities close to inclined slopes, along tributaries are most affected at rapid flows while communities in the flat areas are most affected at extended flows.
- Climate change, insufficient planned development as a matter of flood risks and also increased erosion lead to potentially large economic and social vulnerabilities.
- Taking into account the characteristics of the hydrological regime of the Moldavian Plain, future efforts must directed towards flash-floods studies and their consequences.

References

Apostol L., Buruiană D., Machidon D. 2013. Considerations concerning the spatial distribution of annual precipitation quantities in the hydrological basin of Jijia, *Air and Water Components of the Environment Conference*, Faculty of Geography, Babes-Bolyai University, Cluj-Napoca.

Bogdan O., Niculescu E. 1999. *Climatic Risks of Romania*. Romanian Academy, Geography Institute, Bucharest.

Mihăilă D. 2002. *Moldavian Plain Climate*, PhD Thesis. University of Alexandru Ioan Cuza, Iasi.

Pantazică M. 1974. *Moldavian Plain Hydrography*. Ed. Junimea, Iasi.

****Reports of PHARE 2005/017¬690.01.01 Contributions to the development of Flood Risk Management Strategy.*

****Flood Control, Extreme Meteorological Phenomena and Accidents Associated with Hydro-systems and Accidental Pollution Plans at local level.*

****Synthesis Reports on the Hydro-meteorological Phenomena at County Level.*