FLOOD VULNERABILITY AND RISK FOR BUILDINGS IN RÂMNA'S CATCHEMENT

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ABSTRACT. - Flood vulnerability and risk for buildings in Râmna's catchement. In this article we analyzed the flood risk for buildings in Râmna's cathement. We also evaluated the structural vulnerability of homes based on a scale of analysis. We made hazard maps, vulnerability maps and risk maps for Râmna's cathement, as well as for an area severely affected by July 2005 flooding, located in the sub-Carpathian (Gura Caliței - Dragosloveni). We have shown that protective measures that can be taken to reduce flood risk to households.

Keywords: risk, vulnerability, flood zones, hazard, risk mitigation.

1. Introducere

The presence of water is a favorable factor for habitation, but may become a limiting factor in case of manifestation of extreme hydrological phenomena.

Flooding is defined by J. Ganoulis (2009) as a temporary covering by water of lands which are normally dry. According to the same author flood risk is a combination of probability of occurrence of flooding and its potential adverse effects on health, environment, cultural heritage and economic activity.

Another definition presents the risk as a combination of three elements: natural phenomenon or hazard, elements at risk and vulnerability of these elements. Transposing into an equation could be done as follows: Risk = hazard * exposure * vulnerability (Leone et. al., 2010). According to the authors mentioned above, the risk supposes the existence of a space, a time, an area characterized by some degree of vulnerability and the occurrence of a hazard. They also considere that the purpose of studing the risk and vulnerability, is to serve the development of planning strategies in accordance with the principles of sustainable development.

2. Characteristics of Râmna catchement

Râmna catchement is located in the external Curvature of the Carpathians, overlapping hill units (Vrancea sub-Carpathians) and plain (Râmnic Plain and

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Lower Siret Plain). It has an area of 420 sq. km. The liquid multiannual flow rate is 0.73 mc/s in the sub-Carpathian hills and 0.95 mc/s in the plain. The maximum liquid flow is recorded during the flood of July 2005 and has a value of 514 mc/s in the hilly area and 600 mc/s in the plain.

The location of the villages near rivers, the number of people for each village and population density define the size of the risk in case of flood. Râmna catchement overlaps fully or partially the territory of 17 communes and covers 40 villages with a total population of 25230 inhabitants, with an average of 630.75 people per village.The population coresponds to the 2002 census.

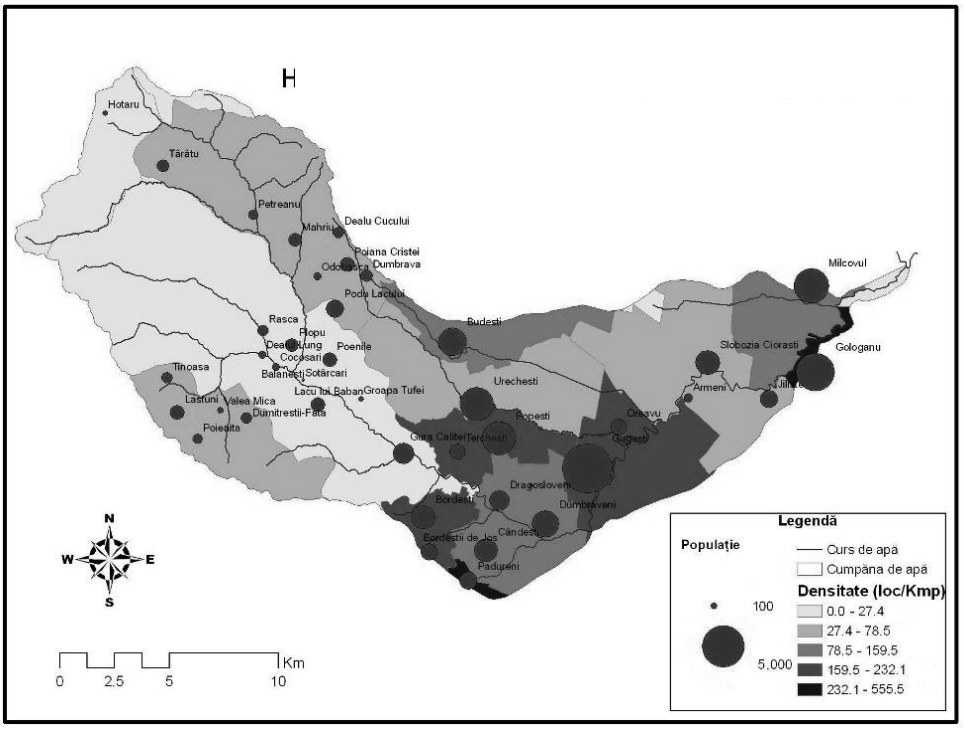

Figure 1. Map of population density and number of inhabitants in the Râmna catchment.

According to these values higher densities are located in the lower half of the basin, in sub-Carpathian glacis area and in plains (Fig. 1). Here, villages have an increased population, most often over 1000 inhabitants. The largest village, with the administrative function is Gugeşti, with a population of 5611 inhabitants. The smallest village has only 4 people and is located in the village of Gura Caliței commune, Balanesti village. In the sub-Carpathian villages have under 1000 inhabitants, often hovering between 200 and 500 inhabitants.

The average population density in the catchement is 78.21 inhabitants / sq km, under the Vrancea county's average (80.8 inhabitants / sq km) and below the national average (PATJ Vrancea, 2008). The average density in the lower half of the basin is 128.95 inhabitants / km and in the upper half is 33.96 inhabitants / km.

Analizing the map materials and the fild observations we can say that the density of living had grown in the areas near the river bed, lower areas, closer to road transport routes, but at high risk of flooding.

3. Database and methodology

The data behind this article was obtained, largely based on surveys and questionnaires conducted with the mayors of flooded villages and the residents whose homes were affected by 2005 flood.

The determination of flooded areas was based on the historical method of setting limits to the extend of the historical flood from July 2005, completed for the inhabited areas by the hydrogeomorhological method and by consulting the 1:5000 topographic plans. The historical method was based primarily on the local testimonies, but also on the graphic materials from the flood of 2005 made by the municipalities and the data they provide on the flooded areas. For the low plane area, downstream from Jilişte, we used to determine the 2005 flooded area the satellite maps corresponding to the date of July 15, 2005, made by SERTIT. The results were rendered in maps made with the program ArcMap 9.2.

4. Census of the buildings flooded in July 2005 in the Râmna catchement

If the 2005 flood, the Râmna catchement was flooded (Fig. 2) in the lower sector by Milcov river as Râmna river flooded the Leica catchement. The analysis in this article will relate only on the areas flooded by the Râmna river within its own catchment.

Thus, in the village of Slobozia Ciorasti 2 villages were affected: Slobozia Ciorasti and Armeni. In Slobozia Ciorasti 3 houses were flooded and two yards, and three other houses were flooded in the village of Armeni. The affected houses are built fron earth and are without an upper floor. After 2005 began the construction of a dam that would have had protected the homes from flooding. Unfortunately it remained unfinished, at this stage, putting even more households at risk because it allows water to pass behind the dam and then no longer allow them to be discharged back into the river. In this case it is possible that many more homes to be flooded during a flood like that of July 2005. In the area of the unfinished dam local gardens are covered by water at each rain for a longer period than usual.

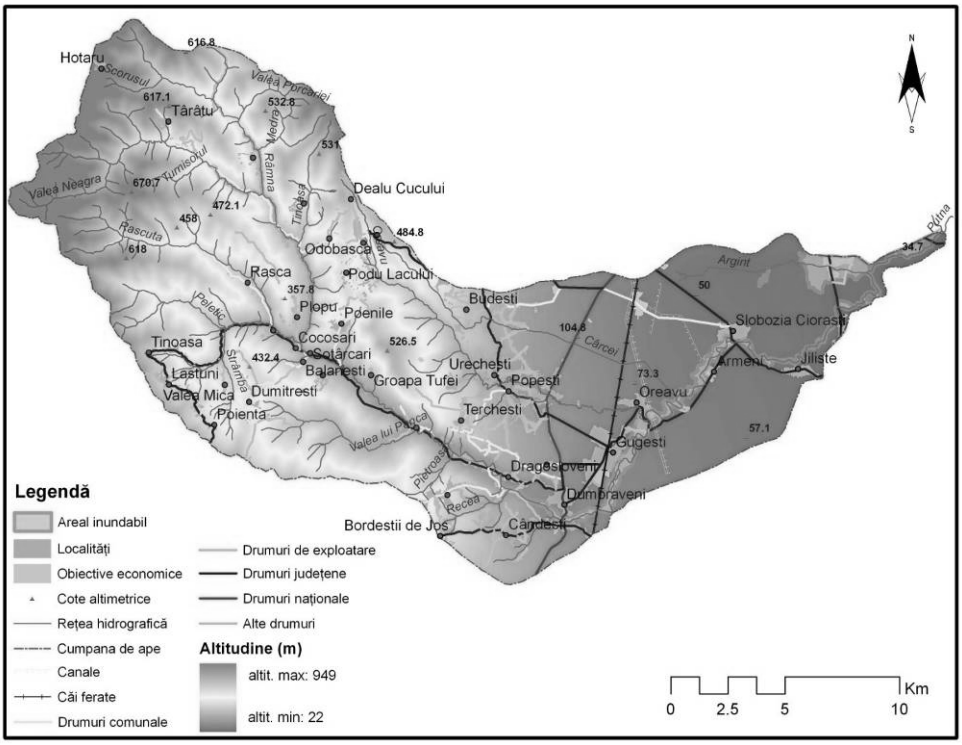

Figure 2. Râmna catchement - flood map.

In the commune of Gugeşti both component villages were affected by floods. Oreavu village risks more to be flooded by Oreavu River rather than by Râmna river. In the Râmna flood plane there are located three houses and a pumping station for water intended for public supply. The 2005 flood did not affect these objectives, but in case of a greater flood their flooding is, however, possible. The risk of flooding is represented by Oreavu river which flooded 10 houses in 2005.

Gugeşti village is affected primarily by floods from the slopes and then, by the Râmna river. In the Râmna's flood plane is located a pumping and water treatment station and a storage and waste transfer plant, located in the north-east of the village. The households are located in the eastern part of the village. Of these, 7 were flooded in 2005, water exceeding 1.5 m for 4 of them. For them it was necessary the intervention to save people caught by flood in the hauses as well as government aid to strengthen or rebuild the houses. One of these houses is now reconstructed with an upper floor, the other houses are without upper floors. In the

south of this area there is another built area situated also in the flood plane. This includes a water pumping station, treatment plant, two economic units and four houses.

In the Dumbrăveni commune two villages were affected by 2005 flood: Dumbrăveni and Dragosloveni. In Dumbrăveni village three households and a sheep cot were flooded. Households are at the confluence with the tributary Valea Bulibaşei. In the period after the 2005 flood vulnerability has increased in the area by building deposits of construction materials and an LPG filling station. Also in Dumbrăveni village two households were affected by landslides that occurred after the 2005 flood. In Dragosloveni village 18 houses were flooded. The affected houses are constructed of earth or brick without upper floors. In the Gura Caliței village two villages were affected by flooding: Gura Caliței and Dealu Lung. Gura Caliței was most severely affected by floods on the Râmna river in July 2005. There were 54 households flooded, a primary school, a community center, a dispensary, a canton of forestry. In Dealu Lung village five households were affected. In the Poiana Cristei commune were indirectly affected by the Râmna and its tributaries flooding, Mahriu, Petreanu and Târâtu villages. In this area houses are affected by landslides produced by floods.

5. Flood vulnerability for households

In case of Râmna catchement, the main elements affected by the floods are the households. The houses has high vulnerability due to the type of material used in construction, to the architectural specificity of the area, e low houses, without un upper floor and to the lack of adaptation of the house to the destructive potential of a flood. These aspects are added to the lack of accurate mapping of flooded areas, areas that should be included in the general urban plans and readjusted to reduce vulnerability.

Gura Caliței and Dragosloveni villages are the most affected by 2005 flood on Râmna, with the largest number of households located in the flooded area. The type of construction of these villages are life-threatening for the locals, and as well for the assets that make up the household. The analysis will focus henceforth on the build area of the two villages.

House vulnerability was analyzed based on the following criteria: the foundation structure, building material, number of floors, possibility of vertically escape, exposition to stream, type of heating and the presence of flood protection measures (Table 1).

Table 1. Structural vulnerability criteria and classes for houses (Barroca, et. al., 2005)

Indicators	Criteria	Class	Vulnerability evaluation
House Vulnerability	Foundation Structure	good (steel concrete, great debth)	1
		average (concrete, cement)	2
		weak (wood, lack)	3
	Building material	good (steel concrete)	1
		average (BCA, brick)	2
		weak (wood, earth)	3
	Number of floors	0	3
		1	0
		2	0
	Vertical evacuate possibilities	existence of a communication with the attic	2
		the presence in the attic of a window that communicates with the outside	0
		none	3
	Orientation	facing the current	2
		lateral to the flow direction	1
	Type of heating	wood	2
		gas	1
		electric power	2
		other	0
	Presence of protective measures	yes	0
		no	2
		partially	1

In the areas affected by floods, in the Râmna catchement, hauses generally have a high degree of vulnerability. Many of this houses are made of earth, without foundation or with wood foundations. Another part is built of brick and have cement or concrete foundations. There are generally houses without upper floors and without possibilities of climbing on the roof from inside, so they provide a low degree of safety in case of flooding. Very few houses are newly built, the material used beeing BCA and concrete foundation. These houses have, in general, upper floors, unlike the older ones, which gives them a lower degree of vulnerability, their owners beeing able to take refuge on the upper floors in case of danger. The type of heating is based on wood, in most cases, leading to increased vulnerability

in case of winter floods. Regarding the flood protection measures for houses, they are not known by the locals. The imposition of protective measures for the houses located in flood-prone areas is necessary, though difficult to adopt because of the low economic possibilities of the population in the area.

Following the completion of the grid analysis and the establishing of the appropriate vulnerability intervals for the categories of vulnerability (high, average and low), I made the flood vulnerability map for houses (Fig. 3) for the most affected area within the Râmna catchement, which includes Gura Caliței and Dragosloveni villages.

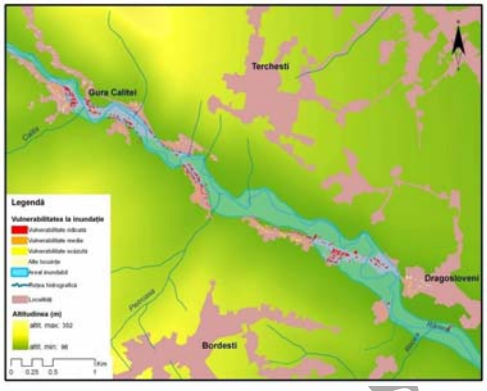

Figure 3. Flood vulnerability map for homes in Gura Caliței and Dragosloveni.

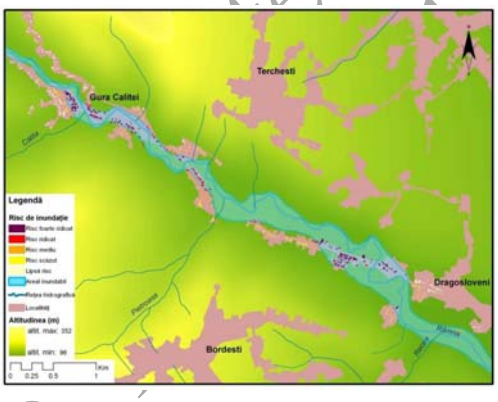

Figure 4. Flood risk map for houses in Gura Caliței and Dragosloveni villages.

6. The flood risk for houses

The flood risk map results by combining the hazard map and the vulnerability map (De Roo et. al., 2007). This map is a necessary tool in the process of organizing activities and urbanistic planning (Sorocovschi, 2002). Knowing the risk areas flood evacuation plans can be made. For the usefulness of these plans it is necessary to accelerate the alert system, given the fact that floods occur quickly in the sub-Carpathian hills.

Flood risk assessment generally integrates hydrogeomorphological approach and historical flood observations with hydrological analysis and hydraulic flow patterns. In this paper we used the historical approach and the hydrogeomorphological one in establishing the flooded areas. We took as reference the July 2005 flood.

The methodology to obtain risk maps (Fig. 4) consisted in determining the risk categories depending on the type of vulnerability and hazard type. In terms of hazard we considered only the height of flooding, based on evidence recovered from the locals and on land altitude values (topographic plans 1:5000).

Human activities have increased the flood risk by carrying out construction in the flood plane. The new homes build in this area of high flood risk have increased the economic losses in the historic flood of 2005. The lower resilience of the population and the high degree of poverty of the inhabitants of these areas makes the risk even higher. According to the PATJ Vrancea the area the most affected by the 2005 flood in Râmna catchement is among the poorest areas of the county.

The ability to cope with the catastrophe was defined as a combination of strength (ability to absorb the impact of the hazard and continue to function) and resilience (ability to quickly recover after losses) (Dow, 1992; Cutter, 1996, Clark et al., 1998 , and Wu et al., 2002, quoted by Rygel et. al., 2006). Poor people have less money to spend on preventive measures, provision for emergency cases and recovery efforts (Clark et al., 1998, quoted by Rygel et. al., 2006). One example are the flood marks that are still visible after 7 years from the historical flood, outside or inside the houses (Fig. 5).

Figure 5. Houses in the flood plain of the Râmna river - traces of the July 2005 flood in Gura Caliței village.

7. Flood risk mitigation for houses

Risk mitigation can be achieved through appropriate actions aimed at the components of risk: hazard, vulnerability and elements at risk.

Intervention in order to prevent floods is achieved by measures that help reduce peak flow and prevent overflow of the water in the flood plane. These measures are carried out at both river bed and flood plane and also in case of the slopes and they are represented by hydraulic works that compose the structural measures. An effective fight against flooding should consider three aspects: retaining rainfall in the area where it fell, local storage of excess water and its discharge to a watercourse after flood danger has passed.

Floods can not be avoided, but human intervention, by land use and hydraulic works, is an important factor, acting to minimize their impact and

magnitude. A special attention should be given to transforming free space in built spaces (Ganoulis, 2009).

Intervention on the elements at risk can be made before or after the dangerous event. The intervention before the flood is achieved by preventing the building in the area of risk and intervention after the flood refers to the displacement of houses located in the risk area.

Building outside flood risk areas needs accurate maps indicating exactly the flooded areas. These maps are currently being implemented in Romania.

Intervention on house vulnerability involves taking a series of flood protection measures, related to the waterproofing of the houses, or to the hydraulic transparency, using appropriate materials to minimize losses. Waterproofing the houses involves the use of impermeable building materials that prevent the infiltration of water through the walls of the house, as well as the use of special mobile devices to prevent water to enter through doors or windows. This measure is recommended in case of short floods and low water heights. In case of long time flooding and great water heights are recommendable the measures that ensure greater hydraulic transparency. These include allowing the water to pass through the house. For this purpose the use of waterproof and easy to clean materials for the inside of the house is necessary. This method also requires the location of household appliances on an upper floor, location of electric plug-ins higher, the possibility of automatically closing the gas supply (Vinet, 2010). Flood protection measures may include also: the supperelevation of housess, the constructing solid foundations (eg. concrete), building an upper floor to provide a place of refuge for residents in case of flood, the creation of openings (windows) to allow the climbing on the roof for houses without upper floors.

To reduce vulnerability the households can be displaced to safe areas, on the basis of knowing the areas with flood risk. There is also need to ensure the houses against natural hazards. Until now, in the studied region, the state intervened to help victims of floods. A new mandatory insurance law for houses came into force this year (2011). This requires owners to ensure, among other risks, against the risk of flooding. In case of house owners in the Râmna catchement there is deficient information on the need to have ensurenses, but those who are informed of this, think, generally, that it is a good initiative.

In flood risk management an important element must be represented by informing people about the risks present in their community and about the methods to minimize these risks. In this respect it is useful to develop in Romania, the concept of risk culture, which includes, in addition to the information, the conservation of the flood memory (Zaharia, 2010).

8. Conclusions

In the Râmna catchement the flood risk for houses exists. The most affected sector is the area between Gura Caliței and Dragosloveni villages. Here a

large number of houses are located in the flood plain of the Râmna river. Structural vulnerability of houses is high. This is due also to the high degree of poverty of the population in the area. This blocks the adoption of flood protection measures that are absolutely necessary, but too expensive for people on the edge of subsistence.

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