Mapping floods risk for the implementation of an efficient management of natural disasters in Romania and Republic of Moldova

Nicuță Precul A.M.[1,*], Nistor-Lopatenco L.[2], Pantaz A.[3]
Technical University "Gheorghe Asachi" of Iasi, Iasi, Romania[1]
Technical University of Moldova, Chisinau, Republic of Moldova[2,3]
alinanicuta@yahoo.com, nistor.livia@gmail.com, pantaz.alexandru@gmail.com

Abstract: *Technological development must be used to support and facilitate the society safety and evolution. Hazard maps, created based on innovative computer software, have the purpose to prevent and reduce material damages, injuries and deaths. The present paper approaches the design and realization of hazard maps with the purpose of reducing the cross-border gaps between Romania and Republic of Moldova on flood vulnerability. The results conclude on prevention measures in case of emergency situations and regional planning at European Union East border for the increase of society safety.*

Keywords*: MAPS, HAZARD, DISASTERS, GIS*

1. Introduction

Reducing the gap between Romania and the Republic of Moldova in the field of action planning in case of emergencies as well as in the strategic approach to natural disasters can be obtained by creating a cross-border hazard management network at the eastern border of the European Union.

The two border countries have different approaches, national policies and action plans on natural hazards management even though they face similar types of natural phenomena. While Romania, as EU member, is committed to submit to its regulations in all the domains, Republic of Moldova, as a Non-EU country, has its own laws and approaches. Still, the lack of information and financial assistance increases the gap between these two countries and, in the face of a natural hazard, shows high vulnerability and risk.

Going from a Micro to a Macro approach of the situation, the present paper presents the analysis performed on a test zone called Ungheni, representing a City in Republic of Moldova. The studies in the Test Zone considered as Micro-Level Approach, were obtained along an international Cross-Border Program and can be further extended to other Cities, along a Macro – Level Approach. Ungheni area, was chosen for evaluation in the paper, based on its high level of hazard risk vulnerability. This particular zone is subjected to multiple hazards, like flooding, soil sliding, earthquake etc., so it would be of great interest to observe the management of these hazards. Considering the wide diversity of potential natural hazards, the present paper focused mainly on the flooding hazard, since it is of greatest significance for the area under consideration.

2. Ungheni Test Zone

Ungheni is an important city with the status of municipality positioned in the central-western part of the Republic of Moldova. It is the residence of the homonymous district. It is located on the eastern bank of the Prut, near the village in Romania, with which it formed in the past the same locality.

The territory of the town of Ungheni coincides with the left slope of the Prut river valley and is fragmented by the network of valleys and ravines of the Delia river valley. On the Prut River, both valleys are located in the western and north-western part of the city, occupying limited territories. The width of the riverbed - 30-40 m, meanders sharply and in some places the deviation from the meadow above the terrace is high and low meadow. The maximum elevation of the meadow is 36.8 - 38.3 m.

The surface of the meadow is partially swamped, sloping towards the riverbed, fragmented by the old riverbed, occupied by ponds and muddy lakes. The largest old riverbed of the water basins occupies an area of 14 ha - between the river and the buildings in Bereşti area. The presence of water basins influences the flooding processes of the Prut meadow territory. [1]

Other territories in the meadow are occupied with buildings, gardens, green spaces, technical installations and other engineering measures: including the damming of the Prut riverbed against floods. On the Delia River, the high and partially low meadow is partially occupied by the waters of the Delia artificial lake. At the mouth of the Delia river in the Prut River, an extensive part of the high and low meadows (in the region of the Ungheni street autodrome) with elevations up to 37.50 m, such geomorphological peculiarities prevail that coincide with the Prut segment. .

The presence of the elements of the river network (streams, old riverbeds, surface of the meadow terraces) are currently modified by intense constructions. [2]

As a result of the flooding of Delia river valley from the accumulation basin, the rest of the meadow is observed as a narrow strip, especially on the right side of the meadow valley. The strip with elevations 40.8 - 41.9 m between the ponds and the second terrace step is muddy, complicated by the railway embankment. [3]

2.1 Road system

The city of Ungheni is crossed by two roads of national importance R1 (Chisinau - Ungheni - Sculeni - Romania) and R42 (Ungheni - Măcăreşti - Bărboieni), through which it establishes transport connections with all the cities, communes and villages of the republic, as well as the neighboring countries Ukraine and Romania. The city stretches for a distance of 9 km along the border with Romania. The average width of the city is about 3 km. Fig. 1 presents the national and local roads from Republic of Moldova.

Fig. 1 *Road map of the Republic of Moldova.*

Ungheni local roads network is composed of 171 streets with a total length of 132.4 km and an area of approx. 0.87 km2. The linear density of the streets in relation to the capitalized territory is 7.9 km / km.

The scheme of the city's road and street network was formed based on the natural relief and the existing constructions, which in itself represent a rectangular system, especially in the central part of the city, divided into neighborhoods measuring 200 x 150 m-200 m. City structure of street network is chaotic.

Taking into account the increase in transportation levels in recent years, changes in the structure of public transport, the number of business trips, and especially those related to the commercial activity of the population, the existing road network with the capacity and minimum technical parameters do not meet the contemporary requirements.

The situation is also aggravated by the lack of alternative possibilities for transport links, which contributes to the formation in the city center of the intercity transport flow in transit, which is about 50%.

The city center also serves as a transshipment hub in the urban public transport network, being one of the main points of arrival and departure of passengers.

Based on the above, it can be seen that the highways in the city center, which are provided for establishing connections with the sectors on the outskirts of the city, do not correspond to its functions and require reconstruction to bring the technical parameters in line with current regulations.

As a result, the National, Roman and Decebal streets are the main streets of the city, here are concentrated many objects with a large number of visits that generate large flows of transport and passengers.

In order to solve this problem, first of all it is necessary to precisely differentiate the streets according to their functional destination with the nomination of the main highways that need reconstruction.

The main streets of the city fulfill the function of highways of urban importance, have rigid road pavement and are in a relatively satisfactory technical condition.

The disadvantage is the unevenness of the width of the roadway and the red lines that are narrowed by the existing constructions. The connection between the city center and the other sectors is established through the streets, many of which are in an unsatisfactory technical condition, or do not even have road signs. As a result, all road traffic goes to the city center. Fig. 2 below details on the types of roads, by category, in Republic of Moldova.

Fig. 2 Types of roads in test area – UNGHENI, Republic of Moldova.

Fig.3 details on Ungheni district roads network, presenting the number of km for each type of category.

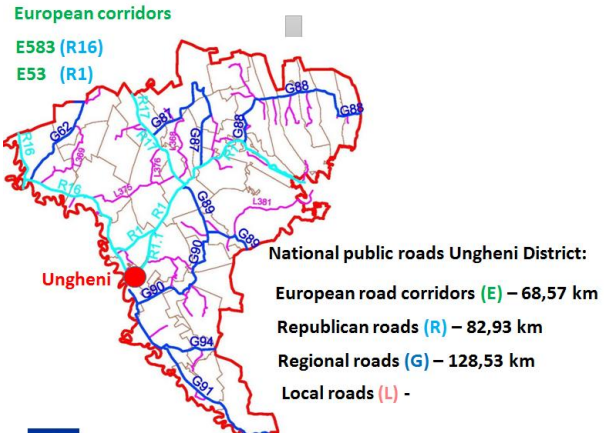

Fig. 3 Ungheni district road network.

2.2 Analysis of the technical conditions of major importance buildings in Ungheni

Structural analysis of constructions (with their expertise), to reduce material damage and loss of life, must be carried out on buildings of major importance or for buildings with an increased risk of natural hazards.

Main building categories are:

- Administrative buildings: local public administration buildings of Ungheni district (the activity and decision-making in exceptional situations should not be stopped);
- Buildings where employees are located, which intervene promptly during natural disasters: Civil Protection and Exceptional Situations Service and Ungheni Police;
- Educational institutions. In Ungheni municipality there are:
  - ✓ 6 kindergartens;
  - ✓ 6 school institutions;
  - ✓ 4 secondary education institutions, colleges, etc;
  - ✓ 2 extracurricular activities institutions;
- Health care buildings (in case of possible natural hazard, with possible victims, they should be treated safely: IMSP Ungheni District Hospital, Consultative diagnostic center, etc.);
- Housing stock, which is in a precarious condition.

Analysis of the technical condition of buildings of strategic importance, provides information and allows: preparation of a list of defects for buildings; formulating recommendations for the prevention of certain risks, regarding measures for the consolidation and / or repair of buildings or the rehabilitation of defective sections of engineering networks. Figure 4 presents few images with the current situation of public buildings.

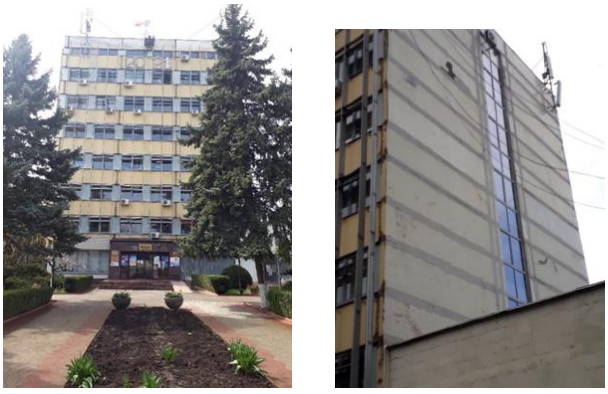

Fig. 4 Ungheni City Hall (including the command post). The technical condition of the building

3. Methodological approach

The analysis was performed based on several cartographic materials namely:

- General urban plan, year 2014;
- Orthophotoplan, 2007-2011, 2016-2020;
- Cadastral plans, year 2014;
- Hydraulic model 2014;
- Land use.
- Topographic surveys

The research consisted of:

- Updating / improving the hydraulic model
- Geometric updating of the terrain - identification of key points in areas with high risk of floods, performing accurate terrestrial measurements (GNSS / GPS receivers) exactly near these areas / points. [7]
- Monitoring the future hydrological status of the study area, by taking into account climate change. This includes a set of analyzes of gaseous emissions (GHG), air pollutants in common with land use, etc., which can identify a potential impact of climate change on precipitation and temperature, and thus on hydrological behavior. [8]

The anthropic factor - the evidence of new constructions, including hydrotechnical ones. [9]

Required components:

- Hardware equipment (Leica RTK GNSS receiver, Adaptive on-the-fly satellite selection, Continuous search for RTK solutions, 99.95% confidence.)
- Info Works ICM software - two components:
  - ✓ hydrological models that provide flood hydrographs on rivers and
  - ✓ hydraulic models that simulate the spread of floods along rivers and calculate the risk of flooding in flood zones.

In the end the procedures must be applied.

As observed in fig. 5, the Target Zone geodetic measurements are being exposed, based on computer software modeling.

Fig. 5 Geodetic measurements.

Based on a hydraulic modeling from 2014, the model results are provided in GIS format. The Flooded areas are calculated using a grid/network of triangular elements (cells) (TIN) as observed in Fig. 6. [7]

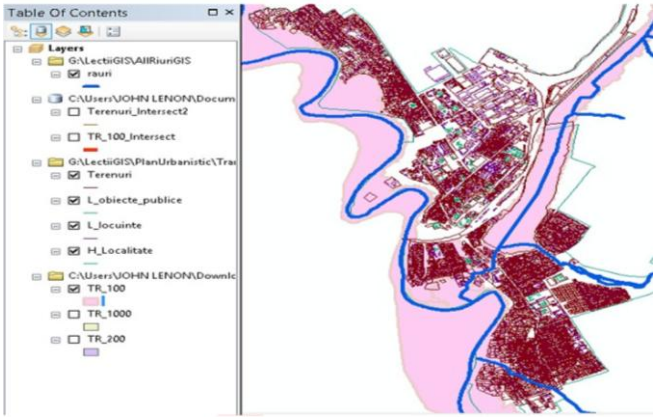

Fig. 6 The General Urban Plan of Ungheni overlapped with the hazard maps (fragment)

Stages of detailed hydraulic modeling implies [10]:

1. Data collection (bathymetry, land topography - Creation, updating of BD);
2. Quantified data flow within the river basin (Analysis of precipitation flow - leaks);
3. Calibration and validation (as appropriate);
4. Interviews with people to determine the level of knowledge about rivers, dams and their state of flood protection, essential aspects for planning system improvements.

Fig. 7 View vectorized data based on Orthophoto

4. Results and discussions on Ungheni Target Zone

The analysis process started with the identification of key points from areas with high risk of flooding (office, land). The expected result of reshaping would be:

- Obtaining flood hazard maps;
- Flood risk assessment (ERI) according to established (updated) criteria;
- Identification of new risk reduction measures (structural, non-structural)

The model should provide information/data on flood extent, depth and flow rate. The elements exposed to the danger of floods in the study area of Ungheni, Moldova are described in table 1 below.

Table 1: *Constructive elements exposed to floods risk in Ungheni.*

Risk	Construction		Land use categories (extra-urban)		Infrastructure (roads)		Town	
Probability	Units	Area (m^2)		Area (ha)	Sections	Length sections (km)	Location	Area (ha)
10% (large)	678	80482.20		264.4	5	4.51	1 Ungheni	518.64
1% (medium)	687	82712.8		265.5	5	4.52	1 Ungheni	520.80

For the scenario with areas with a risk of 1% (average probability), the territory of Ungheni is exposed. In these areas, the risk of floods can affect 687 buildings (82712.8 m^2), plots with various categories of use outside the town (265.5 ha) and 5 sections of road with a length of 4.52 km.

Ungheni, Moldova, is exposed for the scenario with 10% risk areas (high probability). In this area, the risk of floods can affect two buildings with an area of 80482.20 m^2, plots with various categories of use outside the town (264.4 ha) and 5 sections of road with a length of 4.51 km, as observed in Fig. 8. [11]

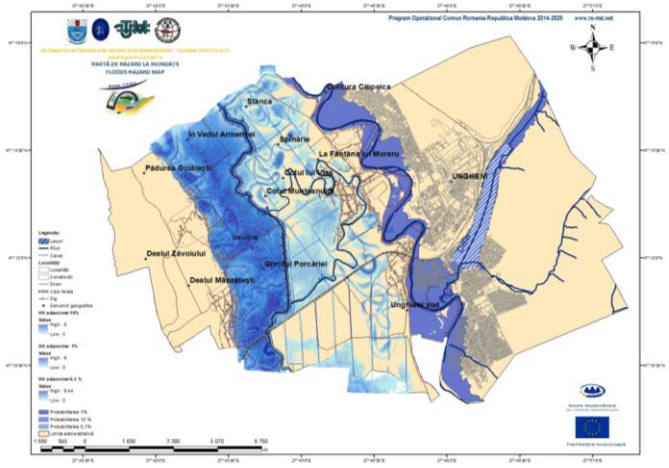

Fig. 8 Flood hazard map

5. Conclusions

- Flood hazard and risk maps should be included in urban planning;
- Communication and cooperation with the public are needed to deal with possible future flood events;
- The legal basis for risk and flood maps needs to be addressed in the near future;
- Mass dissemination of information about the maps must be created and provided details about the possibilities of using them.

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