

**EVACUATION FLOOD ZONE MAPS IN URBAN AREAS AS AN
INSTRUMENT FOR EFFICIENT EVACUATION PLANNING
(CASE STUDY IN BULGARIA)**

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ABSTRACT

In recent times, there have been numerous flood emergency events and disasters - natural and anthropogenic that have threatened people, their health, animals, property etc. When natural disasters such as floods are imminent or have recently occurred, often a large number of people in the affected regions require evacuation. People should be prepared for such situations and should be able to respond adequately and quickly to a particular event. Problems considered in evacuation decision-making include the decision whether to evacuate, and how to ensure safe evacuation of the population through effective coordination of a range of resources.

In this regard, the purpose of this article is to analyze the existing flood evacuation practice in Bulgaria and to show the possibilities that flood risk assessment (flood zones maps) provide for a more efficient evacuation planning.

A methodological approach based on disaster cyclic is applied. According to this cyclic, emergency decision-making in evacuations is divided into three phases: pre-evacuation decision-making, which is primarily concerned with the question of whether evacuation is required; decision-making during evacuation, which is comprised of a variety of decisions related to the transfer of the affected population from dangerous to safe destinations; and decision-making after evacuation, where the principal concern is regulation of the social and psychological responses of the population who have suffered a disaster.

The main findings of the research are developed evacuation maps based on the flood risk assessment, as well as the formulated policy recommendations for improving evacuation planning in Bulgaria.

Keywords: Evacuation flood maps, Risk assessment, Bulgaria

INTRODUCTION

In recent times, there have been numerous flood emergency events and disasters - natural and anthropogenic those have threatened people, their health, animals, property etc. When natural disasters such as floods are imminent or have recently occurred, often a large number of people in the affected regions require evacuation. People should be prepared for such situations and should be able to respond adequately and quickly to a particular event. Problems considered in evacuation decision-making include the decision whether to evacuate, and how to ensure safe evacuation of the population through effective coordination of a range of resources.

In this regard, the purpose of this article is to analyse the existing flood evacuation practice in Bulgaria and to show the possibilities that flood risk assessment (flood zones maps) provide for a more efficient evacuation planning.

The object of the survey is the river section of the River Yantra (within the boundaries of the town of Gabrovo).

MATERIAL AND METHODS

A methodological approach based on disaster cyclic is applied. According to this cyclic, emergency decision-making in evacuations is divided into three phases : pre-evacuation decision-making, which is primarily concerned with the question of whether evacuation is required; decision-making during evacuation, which is comprised of a variety of decisions related to the transfer of the affected population from dangerous to safe destinations; and decision-making after evacuation, where the principal concern is regulation of the social and psychological responses of the population who have suffered a disaster.

For the preparation of the evacuation zones map of Gabrovo a geodata base created during the assessment of the hazard and flood risk is used in the framework of the project "Joint disaster risk monitoring in the Danube border area" under the flood risk assessment methodology developed by the author of this publication.[5]

RESULTS AND DISCUSSION

Institutional and legal risk assessment and evacuation framework

Ensuring the protection of life and health of the population, protection of the environment and property in the events of disasters is regulated in the Disaster Protection Act (DPA). [1] In particular protection against the harmful effects of water, including floods is regulated in the Water Act, 2000. (WA) [2] The DPA describes a number of activities concerning the protection of the population to be carried out in the event of danger or occurrence of disasters. For the purpose of this publication, two of them will be commented – conducting preventive activity and temporary sending out, evacuation, safeguarding and provision of individual means of protection. Preventive action aims at reducing the risk of disasters and in turn includes a number of activities – "analysis and assessment of disaster risks; Disaster risk mapping; Disaster protection planning". The conditions, procedures and authorities of *assessment and mapping of disaster risks* are stated in the "Ordinance for the conditions, order and authorities for carrying out an analysis, evaluation and mapping of disaster risk ", 2012. [3] In particular the assessment and mapping of flood risks shall be carried out in accordance WA requirements. Water Act transposes the three-stage application of the Directive which applies to all kinds of floods (river, lake, urban, etc.): "Preliminary Flood Risk Assessment", "Flood Hazard Maps and Flood Risk Maps", and "Flood Risk Management Plans". Flood Hazard Maps and Flood Risk Maps are designed according to Flood Risk Assessment Methodology in compliance with regulations of Directive 2007/60/EC, published in February 2013. Maps of flood risk areas show the adverse effects of floods for the following probability periods: low-probability floods occurring with a recurrence period of 1000 years, floods with an average probability of occurrence with a repetition period of 100, and floods with a high probability of occurrence with a recurrence period of 20 g. Adverse effects are expressed by the following indicators: 1. Approximate number of inhabitants conceivably affected; 2. Type of economic activity in the area conceivably affected; 3. Installations which may cause additional pollution due to the accident in the event of a flood and the areas of water protection for which there is a chance to be affected; 4. Other significant sources of contamination.

Disaster protection is planned at municipal, regional and national level through disaster protection plans (national, regional and municipal). They shall create in sections for each of the hazards specific to the territory concerned, such as the earthquake, flood and nuclear or radiological emergency parts are required. By the Disaster protection plans hazards and assess disaster risks must be identified. The „flood” section of the disaster protection plans shall prepared taking into account the flood risk management plans developed under the conditions and under the terms of the WA [2]. *The review of the official hazard and flood risk maps prepared by the four Water Management Basin directorates (Danubian, Black Sea, West Aegean and East Aegean River basin areas for basin management) shows that the information contained therein is not sufficient for effective disaster protection planning. Flood risk maps contain too much general information on the approximate number of flood affected populations at the level of the flooded area and do not include characteristics such as age, educational, gender structure of the population, etc. The review of municipal and regional disaster protection plans, part of “floods” in general are not or partially aligned with flood risk management plans. As a result, the protection of the population of flood is planned in a very general way, both in terms of structural and non-structural protection measures.*

Current Bulgarian flood evacuation practice

The conditions and procedures for conducting evacuation and dispersion are regulated by the DPA and the ORDINANCE on the conditions and procedures for conducting evacuation and dislocation. [4] Evacuation and/or dislocation shall be carried out in case of a declaration of emergency or in the event of a hazard risk. Evacuation and dislocation can be immediate (earthquakes, nuclear or radiological situations, accidents involving dangerous substances and materials, plane crashes, forest fires and other hazards) or after warning and disclosure (floods, hurricanes, storms, snowdrifts and ice-icing). All humans and animals from the territory designated for evacuation are subject to evacuation. The following are subject to dislocation: valuable historical and archival documents, scientific and technical documentation; movable cultural goods; medicines, medical devices, etc. Depending on the situation, it may not be possible to carry out evacuation and relocation, but to carry out temporary removals of persons, domestic and farm animals without accommodation and removal of property in safe places. Organized evacuation of humans and animals is carried out through evacuation assembly point (EAP), evacuation centers (EC) and accommodation site (AS).

The planning of evacuation and/or the dispersion is carried out at municipal, regional and national level, and plans are prepared for the relevant parts of the disaster protection plans under the DPA. These plans include the seats of the EAP, EC and AS, as well as the main and backup routes for evacuation and the organization of the movement. The accommodation of the evacuees and the preservation of the dispersed cultural and material valuables as possible shall be planned on the territory of the relevant or the nearest neighboring municipality (region). The estimates for evacuation and dislocation for the relevant parts of the municipal plan for disaster protection are prepared by the mayor of the municipality/Governor in cooperation with representatives of the offices and legal entities relevant to this activity in the territory of the municipality/district.

The organization of the activities of dislocation and transport of persons and animals, removal and relocation of cultural and material valuables shall be carried out by the EAP immediately after disclosure. Priority is to evacuate children, sick and elderly people. People from social, medical and healthcare facilities are evacuated by taken care of the staff of the establishment concerned.

Regardless of the requirements of the Ordinance on the Conditions and Procedures for Conducting evacuation and dislocation prevalent of the disaster protection plans, for part "floods", at municipal and district level, no plans for evacuation and recovery were prepared. In cases where such plans are developed due to lack of information and capacity they are very common and cannot meet all the requirements of the Ordinance on evacuation and dislocation. A number of factors must be taken into account for the effective planning of evacuation and the displacement of population. In potentially flooded areas in different scenarios (HQ20/5%, HQ100/1%, HQ1000/0.1%) besides the population there is a number of economic sites that are also covered. It is therefore necessary to take into account, in the first place, whether the evacuation and/or the dislocation takes place during the day or at night. In the event that it is during the day, the number of affected, which must be evacuated from the threatened area is large, but a very small proportion of the affected has to be taken out of their homes and to be provided with accommodation, since a large number of people falling into the area only work in it. It is assumed that only about 10% of the affected live in the flooded area and must be evacuated. Secondly, it should be provided that about 20% of the affected will be evacuated with their own transport, and that part of the affected population will be evacuated to their own villas and/or holiday houses or to relatives and friends living outside the flood area. This will further relieve the municipality's estimates of the provision of transport and accommodation. There must be readiness to evacuate first of all children's and educational institutions, as well as social homes. For these sites there must be provisional estimates and must be evacuated with priority, and in their evacuation the voluntary units under the DPA should be included as well.

In the potentially flooded areas are located many cultural and historical sites, in which are located cultural and material values. They shall be subject to a dislocation and estimates which include the type, quantity and place where the material and cultural values must be dislocated and those shall be prepared by the heads of the sites. Additional information on the so called "human factor" is necessary for effective evacuation planning and dislocation. This information includes age structure, gender, educational structure, etc.

Efficiency gains in evacuation planning and dislocation can be achieved through the preparation of evacuation maps of flood-prone settlements, as well as all necessary information for this to be summarized in the so-called "Card Passport for evacuation zones under different flood scenarios". (HQ 20/5%; HQ 100/1%; HQ 1000/0.1%)

Evacuation flood zone maps, as an instrument for efficient evacuation planning – Gabrovo case study

For the basis of the map "evacuation zones of the city of Gabrovo at depth of flooding HQ1000/0.1%" are used: a digital orthophoto card, a satellite image, a cadastral map or a Google image – Earth or a combination of them. The territorial range of the maps is determined by the scope of the flooding zone of floods with different probabilities. The size of the maps is A3, and the orientation of the map sheet is a landscape. (Fig.1)

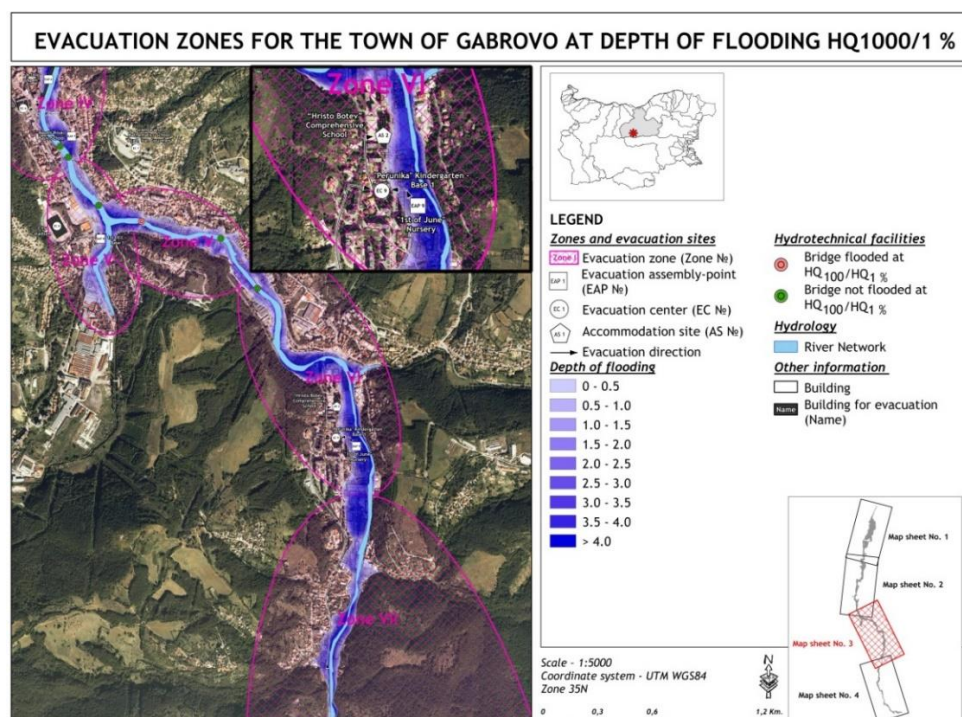
To determine the number of evacuation zones, the following criteria are proposed: *the length of the river section* of the River Yantra with a significant potential flood risk, *the potentially affected inhabitants at the building level*, *the spatial location of the sites from the critical Infrastructure*. The number and spatial location of Evacuation Assembly Points (EAP), Evacuation Centres (EC) and Accommodation Places (AP) in the different zones is determined on the basis of the criteria specified in Table.1

Table 1. Criteria for number and spatial positioning of evacuation sites

	EAP	EC	AP
Distance to main routes, km	✓	✓	
Within the municipality borders			✓
Within the flooded area borders, water depth	✓		
Affected hydro technical Infrastructure (bridge)	✓	✓	✓
Residents affected, number	✓	✓	✓
Critical infrastructure assets, number	✓	✓	✓
Nutrition organization		✓	✓
Availability of water source	✓	✓	✓
Heating capability	✓	✓	✓
Medical and psychological help point			✓

The passport of the evacuation zone map of the city of Gabrovo at depth of flooding HQ 1000/0.1% is prepared on the basis of official statistics, received during the official Census of the Republic of Bulgaria in 2011. It includes indicators showing the number of children, elderly and sick people who, according to the Ordinance on evacuation and dislocation are being evacuated with priority. In addition, there are indicators included on the number of households that have their own transport and have villas and/or holiday houses. It is assumed that these households will evacuate independently and need not be included in the estimates.

The river section which is subject to research of the Yantra River is 8 km long. (Within the boundaries of Gabrovo) The total number of potentially affected population is 3 858 inhabitants. A total of 19 critical infrastructure objects have been identified. Based on these criteria, the river section is divided into 7 evacuation zones. (Fig.1)


Figure 1. Evacuation Zones of the city of Gabrovo at depth of flooding HQ1000/0.1%

According to the criteria in Table 2. 10 EAP, 10 EC and 2 AS are planned to be opened. During the planning of the routes, it is considered which of the bridges built on the river Yantra are flooded at depths of water HQ_{1000/0.1%}.

Table 2. Number of evacuation sites in evacuation zones

Evacuation site	I zone	II zone	III zone	IV zone	V zone	VI zone	VII zone
EAP, number	1,2	3,4	5	6,7	8	9	10
EC, number	1,2	3,4	5	6,7	8	9	10
AS, number		1				2	2

The Passport of the evacuation zones map of Gabrovo is presented in Table 3.

Table 3. The Passport of the evacuation zones map of Gabrovo at depth of flooding HQ 1000/0.1%

Indicators	Areas						
	I zone	II zone	III zone	IV zone	V zone	VI zone	VII zone
Residents/inhabitants affected, number total	181	204	293	436	1225	82	1437
Number of homes with a car	36	41	59	87	245	16	287
Number of homes with a villa or holiday house	18	21	29	44	123	8	145
Number of women	89	120	189	237	754	45	1308
Number of people under the working age	15	36	86	99	134	5	265
Number of people over the working age	55	49	96	158	258	24	439
Number of persons with reduced working capacity over 16 years	35	15	28	6	36	12	45

CONCLUSION

As a result of the study a number of policy and institutional recommendations can be formulated for improving evacuation planning in Bulgaria

- Plans for disaster protection, part of Floods under the DPA shall be developed on the basis of the information from the hazard and risk maps;
- To develop a national methodology for the preparation of the population evacuation maps in different scenarios (HQ 20/5%; HQ 100/1%; HQ 1000/0.1%);
- The disaster protection plans, part "flood" with the flood risk management plans and the water management plans must be synchronized into the DPA and WA;
- The population evacuation maps to become a mandatory attribute of the estimates for evacuation and dislocations;
- Plans for evacuation and dislocation must be prepared on the basis of the information from the evacuation maps, which to become a mandatory attribute to them;
- To develop a mechanism allowing annual updating of the indicators for flood affected populations applicable at different administrative and territorial levels – municipal, regional and national. This will allow an annual update of the evacuation and recovery plans.

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