DEVELOPMENT OF A SUSTAINABLE FLOOD DISASTER MANAGEMENT PLAN FOR TRANSBOUNDARY RIVER BASINS

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Abstract

The paper discusses the problems emerging from disaster prevention and flood risk management on transboundary areas. The special focus is given to the flood hazard, vulnerability and risk assessment, which have strong influence on disaster and/or emergency management plans. The author discusses difficulties of harmonizing activities aiming at risk reduction and flood prevention. Considering Europe, there are still efforts to harmonise flood management on transboundary areas even though EU launched "Directive on the assessment and management of flood risks" six years ago. The aim of the Directive is to reduce and manage the risks that floods pose to human health, the environment, cultural heritage and economic activity. The overall goal of the transboundary river basins is to achieve a long term and sustainable approach for managing the risks of floods and, consequently, manage emergency situations. Obviously, there is no unique solution so the approach should be flexible enough to apprehend all particularities of national legislatives and current measures on transboundray areas. The paper systemises problems, tries to find common answers for such complex systems and proposes methodological approach for disaster response related to floods in transboundary areas.

Introduction

Flooding events in the river basins cause direct damage to property and infrastructure as well as disruption of normal life. Floods are the most common disaster in Europe as well as the most costly one (EC, 2010). The European river basins are examples of strong anthropogenic impacts and it is expected that flood risk might also increase as a consequence of the climate change and human interventions. Therefore, in the area of disaster management, development and implementation of a sustainable flood disaster management plans at national levels advanced the most.

In river basins shared by several countries the flood disaster management plan should be set as transnational effort for the benefit of various stakeholders. For such complex system and shared flooding prone areas by several countries, the flood forecasting and warning is a prerequisite for successful mitigation of flood consequences. River basin riparian countries should consider developing system for timely and reliable flood warning, flood forecasting and information sharing based on all relevant national institutions in charge for water

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management. Besides flood warning and forecasting systems, which run under international cooperation, countries develop flood disaster management plans usually depending on the national legislative and good practice.

The development of the sustainable flood disaster management plan is primarily based on the vulnerability, hazard and risk assessment. Natural phenomena such as floods including flush flooding events are analysed through probability of flooding events with hazardous consequences. Since, flood disaster management largely depends on reliable risk assessment an adequate and flexible risk assessment methodology is crucial for finding common solution for transboundary river basin areas. Mapping risk using common principles and methods in a simplified but comprehensive way could be a solution.

Methodology

Flood risk management is a basic component of a flood disaster management, basically for flood prevention and preparedness. Therefore, by defining common risk assessment methodology for transboundary areas, the whole river basin disaster plan could be managed smoothly and effectively. As EU working paper on Risk Assessment and Mapping Guidelines for Disaster Management (EC, 2010) states, even achieving a common terminology remains a challenge, so finding common risk assessment methods are even more difficult. However, three terms most frequently used to description of natural phenomena impact to the people and goods are hazard, vulnerability and risk.

For a natural disaster risk assessment the most common approach defines risk as (EC, 2010):

$$\text{Risk} = \text{hazard impact} * \text{probability of occurrence}.$$

If hazard impact and disaster occurrence are dependent on each other, these terms must be expressed as a functional relationship, not just as a product. If the impacts are dependent on preparedness or prevention, like structural and non-structural measures for flooding the impact could be expressed differently.

Usually, for analysis of natural hazards like flooding, impacts are expressed in terms of vulnerability and exposure. Vulnerability V is defined as the characteristics and circumstances of a community, system or asset that make it susceptible to the damaging effects of a hazard. Exposure E is the totality of people, property, systems, or other elements present in hazard zones that are thereby subject to potential losses (EC, 2010):

$$\text{Risk} = f(p*E*V).$$

According to the EU Flood Directive, flood risk is defined as a combination of the probability of a flood event and of the potential adverse consequences (impacts) for human health, the environment, cultural heritage and economic activity associated with a flood event. The probability of flood event is likelihood of occurrence of a hazard of certain intensity. The hazard impact could be expressed through a flood extent, water depths or water level, the flow velocity or the relevant water flow. Since the consequences are directly related to the vulnerability of the areas, describing their potential to be harmed, flood risk is commonly defined as:

$$\text{Flood Risk} = f(\text{Hazard, Vulnerability}).$$

Considering above-mentioned relations, it is clear that risk could be calculated by assessing hazard/impact and vulnerability for a certain probability of the flood event, for example for 100-year return period. Flood hazard is calculated with results of hydraulic modelling using floodwater velocity and/or floodwater depth taking into account duration of the flooding, if possible. While hazard could be seen as technical value evaluated from the mathematical models, vulnerability assessment is more comprehensive and is sensitive to country's perception of the values of goods, assets or population activities. Consequently, it is usually challenging to harmonise vulnerability assessment on transboundary areas. Therefore, an appropriate risk assessment depends on a vulnerability assessment as its most sensitive part.

The approach that is proposed herein is to use minimum requirements principle in order to meet common good practice of the countries. It is demonstrated during evaluation of the initial vulnerability study for the Sava River Basin (Figure 1).

Figure 1: Sava River Basin as a part of the Danube River Basin (ISRBC, 2009)

Flood vulnerability methodology for transboundary river basin areas

Generally, the vulnerability assessment usually comprises a degree of awareness and preparedness before and during the floods, as well as resilience capacity during and after the floods. The vulnerability assessment defines the relation between flood characteristics and damage. This relation is different for different types of humans and goods, depending on their characteristics.

Vulnerability analysis should define minimum requirements for vulnerability assessment in the river basin shared by several countries. The principle and scheme serves primarily for transboundary areas as a minimum platform for further flood risk assessment and flood emergency plan. However, riparian countries could enhance and adjust a proposed scheme according to their own needs and priorities. It is also recommended that countries should develop the reference damage functions established theoretically or empirically based on flood damage data or for example loss of life or injury functions for people exposed to floodwaters.

During initial flood vulnerability evaluation for the Sava River Basin, the most important challenges were:

- different levels of adjustments to the EU legislative,
- different methodological approaches, as well as lack of methodological approaches for certain issues.

The problems are solved by proposing flexible deadlines, leaving the countries to flexibly adapt to the changes and finding a compromise methodology, which minimises requirements and maximises an effect

For the purpose of flood risk management for the initial vulnerability assessment of the Sava River Basin, and in accordance with European Flood Directive for flood risk maps, the minimal requirements for vulnerability is defined by five criteria (Figure 2):

- Population density,
- Protected areas – nature,
- Cultural heritage,
- Economic activities,
- Special structures and objects.

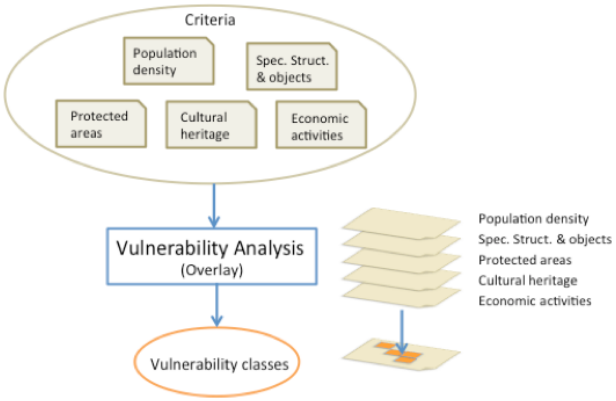

Figure 2: Vulnerability assessment scheme (Andricevic et al, 2013)

Each criterion has three classes/levels defining vulnerability: high, moderate and low. Consequently, an overall vulnerability is classified as:

1. High vulnerability,
2. Moderate vulnerability,
3. Low vulnerability.

Criteria are presented spatially. Since majority of the data are being derived from CORINE Land Cover classification, the most practical approach to structure criteria values is a grid (for ex. 100 x 100 meters cells). Grid cells are classified according to each criterion, thus having five attributes: C1, C2, C3, C4, C5. For each cell vulnerability is calculated using the following rule:

$$\text{Vulnerability Level} = \text{Max}\ (C1, C2, C3, C4, C5),$$

where

$$\text{High} > \text{Moderate} > \text{Low}.$$

The cell vulnerability level is the maximum value among the criteria levels.

Population density

Population density over 500 inhabitants per square kilometre defines expected density for urban areas in SRB. For low populated areas it is expected to have less than 100 inhabitants per square kilometre. The classes are:

1. High vulnerability - greater than 500 inhabitants per square kilometre,
2. Moderate vulnerability - between 100 and 500 inhabitants per square kilometre,
3. Low vulnerability - less than 100 inhabitants per square kilometre.

Protected areas – nature

Categorization of the protected areas is developed in accordance with definition of protected areas by International Union for Conservation of Nature and Natural Resources. Special attention should be paid to potentially affected protected areas identified in Annex IV(1)(i), (iii) and (v) of EU Water Framework Directive, i.e. water designate for human consumption, recreation, bathing as well as protected habitats or species. The classes are:

1. High vulnerability – strictly protected areas where human visitation and impacts are rigorously controlled and/or limited (for ex. categories Ia, Ib and II, defined by International Union for Conservation of Nature),
2. Moderate vulnerability - protected areas cantered on particular natural feature, fragments of ecosystems or habitats (for ex. categories III and IV, defined by International Union for Conservation of Nature),
3. Low vulnerability - protected areas like cultural landscapes altered by humans, natural areas where biodiversity conservation is linked with sustainable use of the natural resources (for ex. categories V and VI, defined by International Union for Conservation of Nature).

Particular attention should be paid to the wetlands and marshes such that flood maps and above classification should be reported only for a low probability flood event.

Cultural heritage

Cultural heritage includes tangible culture such as buildings, monuments, landscapes, books, works of art, and artefacts, etc. This criterion also comprises the museums and similar facilities that store cultural heritage. The riparian countries shall define importance of their cultural heritage. The classes are:

1. High vulnerability - World heritage (UNESCO) or high national importance,
2. Moderate vulnerability - national or regional importance,
3. Low vulnerability - local importance.

Economic activities

This criterion is related to economic activities and their importance to economy: national, regional or local. The criterion has high level of abstraction. Therefore each riparian country has to define particular type of activities through land cover/use categorization and estimate importance to the economy. For transboundary areas a special attention should be paid to avoid eventual discrepancy in judgment. The classes are:

1. High vulnerability - areas with importance to national economy,
2. Moderate vulnerability - areas with importance to regional economy,
3. Low vulnerability - areas either without any importance or with importance to local economy.

Special structures and objects

This criterion concerns structures and objects that are either essential for functioning of society or economy especially during floods or could cause pollution and derogate health condition of the population in flooding conditions. Structures and objects that are either essential for functioning of society or economy are known as critical infrastructure (water supply systems, energy networks, telecommunication systems, major roads and railroads, etc.), structures and objects that could cause pollution according to the IPPC Directive Article 1, and listed activities in IPPC Directive Annex I. The classes are:

1. High vulnerability - structures and objects having national or transnational influence,
2. Moderate vulnerability - structures and objects having regional influence,
3. Low vulnerability - structures and objects having local influence.

If the countries have already classified sources of pollution separately, according to the IPPC directive, they could be easily combined with critical infrastructure objects into a single criterion. Alternatively, countries may decide to have sources of pollution as a separate class for specific sensitive areas having same classification as the criterion Special structures and objects.

For the purpose of initial flood vulnerability assessment of the Sava River Basin four out of five criteria have been evaluated (Figure 3). Data related to cultural heritage were not available during the evaluation. The result of the initial vulnerability analysis is shown on the Figure 4.

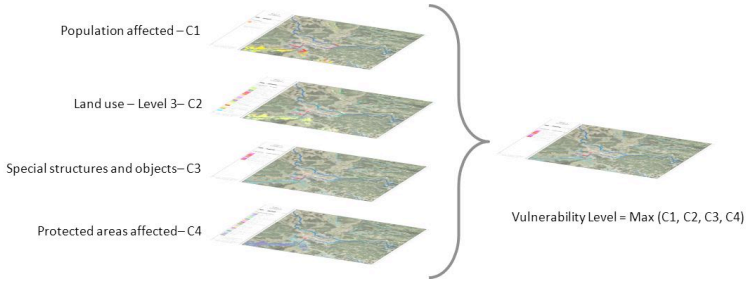

Figure 3: Criteria for initial flood vulnerability evaluation (Andricevic et al, 2013)

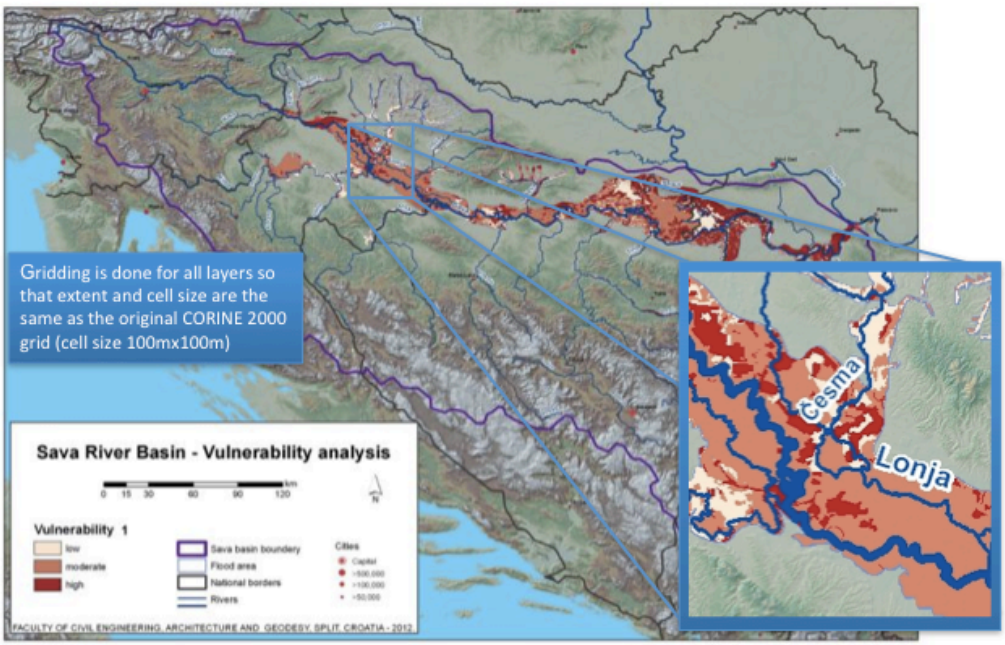

Figure 4: Flood vulnerability assessment for Sava River basin - Q_{100} flood scenario (Andricevic et al, 2013)

Discussion and conclusion

There have been many efforts in harmonisation the cross-border interoperability of emergency services during the disaster, it is also important to do maximum before disaster strikes, such as harmonisation of flood risk assessment for transboundary areas. In such way emergency and disaster management plans will include cross-border and transboundary issues during preparation phase.

Harmonisation of flood risk assessment for river basins shared by several countries highly depends on vulnerability assessment on transboundary flood prone areas. The answer could be a use of common principles for such areas after detail analysis each country's system. The result is a model at higher abstraction level, so each country could easily fit into it. Taking into account good practice, a best way to develop such common methodology is to establish a coordination body, which will direct countries in their effort to find best solution transboundary areas.

The main conclusions and lessons learnt drawn from the initial flood vulnerability assessment performed on the Sava River Basin are:

- Methodological flexibility for transboundary areas taking into account countries' particularities should be achieved.

- There is a necessity to find minimal requirements that could give feasible solutions thus minimise both costs and effort.
- A special attention should be paid for transboundary areas to avoid eventual discrepancy in judgements while defining vulnerability criteria classes. Even though the assessment has been done as an initial appraisal of the situation in the Sava River Basin, a problem has been recognised and a mandatory joint assessment for transboundary areas should be recommended.

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Author Biography

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