MAPS IN THE CONTEXT OF THE EUROPEAN FLOOD RISK DIRECTIVE

Maria Mavrova-Guirginova, Denislava Pencheva, Maria Belyashka

Abstract. *The paper deals with maps which are required by the Flood risk directive. Here are examined the different types of maps, the mandatory and non mandatory, their content, specific characteristics and uses. Also is given the concept of flood risk, some basic information about the needed data for the production of the maps and an example for their provision.*

Key words flood, maps, European flood risk directive

Affiliations:
Assoc. Prof. Eng. Dr. Maria Mavrova-Giurguinova
University of Architecture, Civil Engineering and Geodesy
Bul. Hr. Smirnenski 1, Sofia
margir_fhe@uacg.bg

Eng. Denislava Pencheva, PhD student
University of Architecture, Civil Engineering and Geodesy
Bul. Hr. Smirnenski 1, Sofia
d.pencheva@yahoo.com

Eng. Maria Belyashka, PhD student
University of Architecture, Civil Engineering and Geodesy
Bul. Hr. Smirnenski 1, Sofia
m_belyashka@yahoo.com

1. INRODUCTION

Due to the climate changes and the increase of appearance of natural disasters, more precise flood events, the European parliament published Directive 2007/60/EC on the assessment and management of flood risks on 23 October 2007. It aims to reduce the adverse consequences on human health, the environment, cultural heritage and economic activity associated with floods in the Community. The European Flood Directive (EFD) sets out the requirement for the Member States to create flood hazard maps and flood risk maps.

The aim of present paper is to generalize the types of maps and requirements for their production. Here are given some basic explanations about the data needed for mapping the parameters.

2. MANDATORY MAPS IN THE RISK ASSESSMENT

2.1. Flood hazard maps

The two main types of maps depending on these flood parameter are: flood extent maps and flood depth maps.
According to the European Flood Risk Directive flood hazard maps have to be produced for the following scenarios:

(a) floods with a low probability, or extreme event scenarios;
(b) floods with a medium probability (likely return period ≥ 100 years);
(c) floods with a high probability, where appropriate.

2.1.1. Flood extent maps

The flood extent maps are the most used flood maps. They display the areas which are inundated for specific scenario. In some European countries are produced historical flood maps, which are based on real events, occurred in the past, not only for hypothetical events. Every single scenario is showed on particular map.

Usually in the practice flood extent is displayed with blue colour and the scale depends on the area – for the urban areas is recommended detailed scale (1:2 000 to 1:25 000) and for rural areas – smaller scale (1:100 000 to 1:1 000 000).

There are several main uses of these specific maps. They serve as a base for production of risk maps and danger maps. Also they are used in flood risk management and spatial planning.

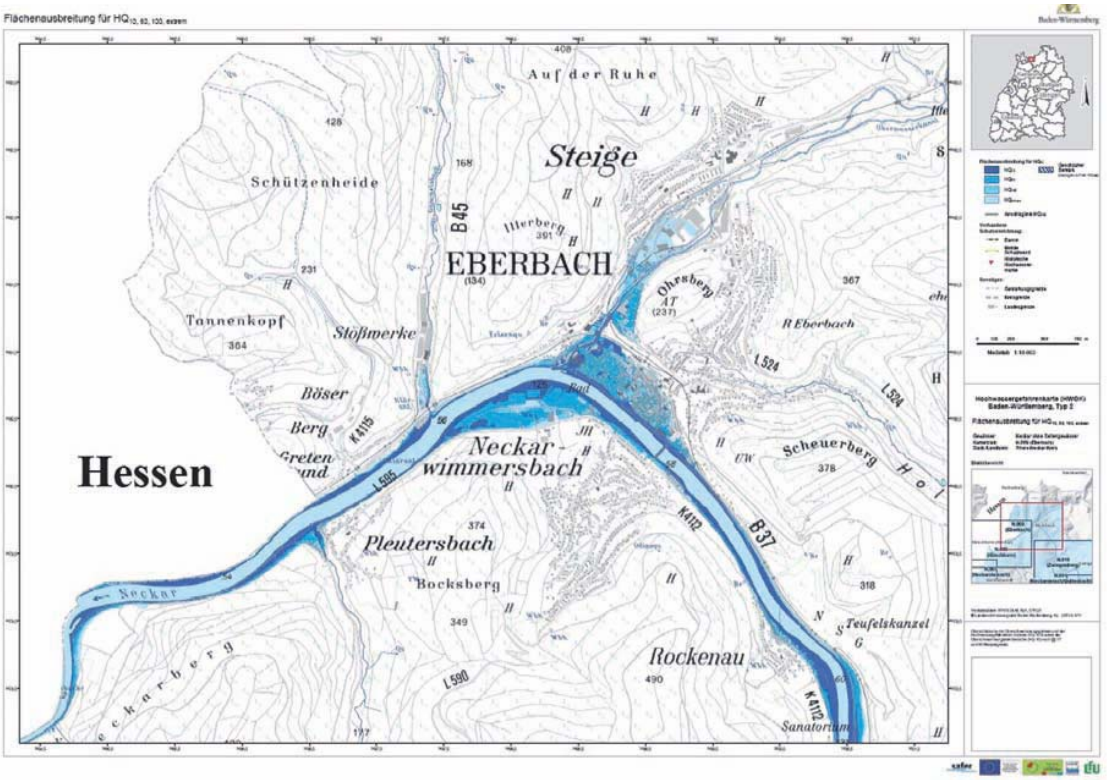

Figure 1. Example of a flood extension map from Baden-Württemberg (Neckar) for return period of 10, 50 and 100 years

2.1.2. Flood depth maps

The flood depth maps show the water depth in the flooded area. They are based on the flood extent maps – after the determination of the water extent, in this boundaries is calculated the water depth. They are produced for the same return periods as the flood extent maps. The depth is given in centimetres or meters, as it is appropriate.

In the different countries are used different colours – from shades of blue to red, yellow and green. The scales are the same as for the flood extent maps – large scales for urban areas and medium and small scales for rural areas.

These maps are very useful for risk management an urban planning.

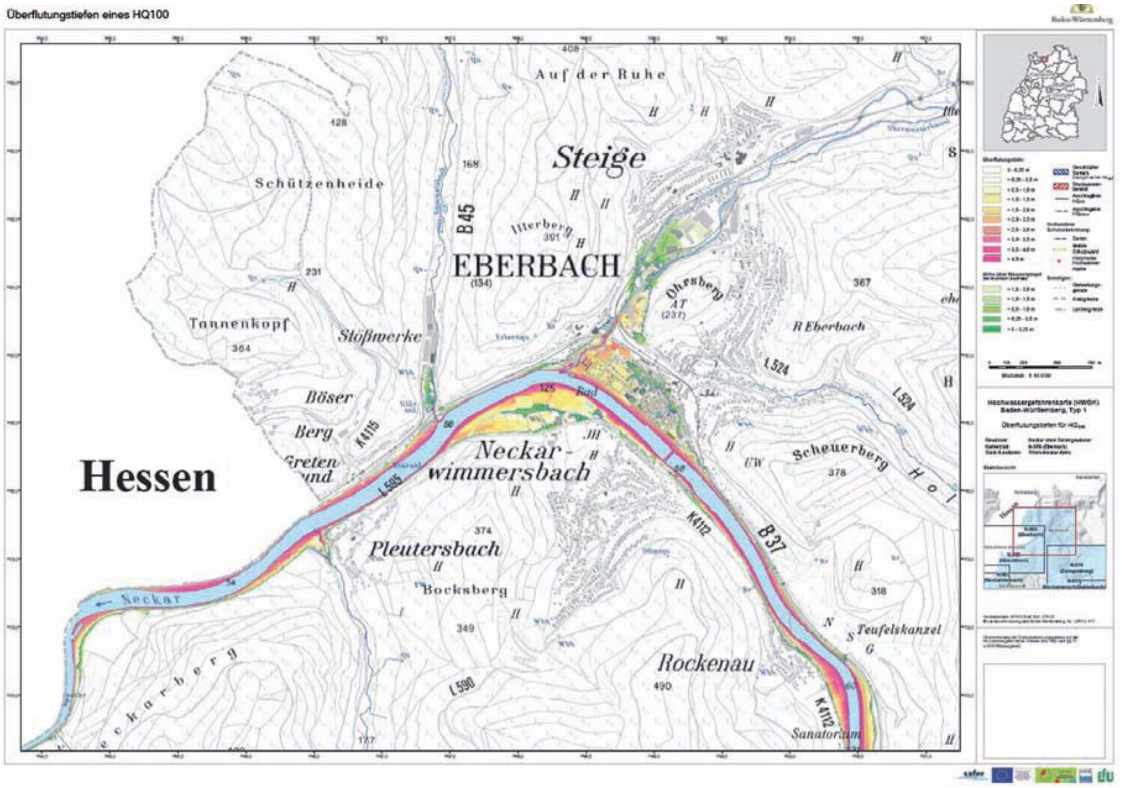

Figure 2. Example of flood depth map (Neckar river)

2.2. Flood risk maps

According to the European Flood Directive shall risk maps shall show the potential adverse consequences associated with floods, expressed in terms of the following:

(a) the indicative number of inhabitants potentially affected;
(b) type of economic activity of the area potentially affected;
(c) installations as referred to in Annex I to Council Directive 96/61/EC of 24 September 1996 concerning integrated pollution prevention and control3 which might cause accidental pollution in case of flooding and potentially affected protected areas identified in Annex IV(1)(i), (iii) and (v) to Directive 2000/60/EC;
(d) other information which the Member State considers useful such as the indication of areas where floods with a high content of transported sediments and debris floods can occur and information on other significant sources of pollution.

2.2.1. Conception of risk

The European Flood Directive states: "Flood risk is the combination of the probability of a flood event and of the potential adverse consequences to human health, the environment and economic activity associated with a flood event."

[2] says that the risk may be calculated as follows:

$$\mathbf{Risk = C * p_h} \qquad (1)$$

where **C** is the potential adverse consequence ((taking into account factors such as exposure and vulnerability) and $\mathbf{p_h}$ the probability of the hazardous process. Risk is expressed as a potential loss in a particular area (e.g. ha, km2) within a given period of time (in general one year).

$$\mathbf{C = V * S (m_h)*E} \qquad (2)$$

where **V**, **S** and **E** are the vulnerability parameters:

V = value of the element at risk: in money terms or human life.
S = susceptibility: damaging effect on element at risk (as a function of magnitude of hazard; e.g. depth-damage and damage-duration curves (for example from FHRC Middlesex)). The susceptibility ranges from 0 to 1.
E = exposure: the probability of the element at risk to be present while the event occurs. The exposure ranges from 0 to 1.

2.2.2. Vulnerability maps

Vulnerability maps contain information about the vulnerability parameters like population, economic activity and environmental issues, potentially affected by a flood (Handbook, 2007).

The information about the population is characterized by the distribution of the people and the buildings and any vulnerable group.

The vulnerability maps contain information about the affected economic activity which depends on the different types of land uses (agricultural land, residential areas and infrastructure).

On the maps are shown potentially affected installations causing pollutions as well. This includes waste water treatment plants, chemical industry, agricultural warehouses for fertilizer and any other installation which can cause pollution in case of collapse and malfunctioning.

For detailed information like single buildings or some special objects are appropriate large scales (1:5 000 to 1:25 000), for infrastructure like roads or agriculture can be used small to medium scales (1:100 000 to 1: 250 000) and for information about some town or village – 1:100 000 to 1:500 000.

These maps can be used for land use planning, emergency management, to determine damage.

2.2.3. Other useful information which can be shown on risk maps

According to the European flood risk directive the Member States can map any information which they consider useful (EFRD, article 6, 5d).

Such type of information can be existing flood defences. Floods in the floodplains can be determined without taking into account flood defences. The protected areas can be marked with hatch or in other way. Other way for modeling the floods is to accept the failure of the defences and model different scenarios.

Other information can be flood damage. The flood damage maps show the potential damage from a particular flood event in monetary units per land unit.

This type of maps can be used in flood risk management, emergency management and decision making.

3. NON MANDATORY MAPS IN THE RISK ASSESSMENT

3.1. Flow velocity and flood propagation maps

The European flood directive asks for maps which represent the flow velocity, where appropriate. Specifically for that kind of map, the flood hazard in a particular location is represented by the velocity of the flow water (or sediment in case of debris flow) or by the velocity of the flood propagation. There are deferent examples in the European practice for flow velocity show on the maps. The flow velocity can be shown as vectors, the length of the vector representing the velocity; as fine lines for the speed and direction of the flow. It can be shown also by colour shading which present the speed from 0 to 10 m/s. The flood propagation in the mapping area is frequency presented in steps of hours (24 hours) or days defined in discrete scale.

The flow velocity map is usually used in planning of flood defence measures or any structure within the flood area, as tool for technicians, base for the flood alert planning in the affected area.

The flood propagation map is used as planning tool for emergency response, evacuation schemes, implementation of temporal flood protection measures. The information requires a well-functioning early warning and alert system.

The flow velocity is highly localized information which has to be represented in a detailed scale (1:1000; 1:5000). In general, the flood propagation covers large areas. Accordingly, the scale of the respective maps is rather small (1:250 000).

3.2. Flood danger maps

The flood danger map combines various flood parameters to form a level (degree) of danger (depth, velocity, debris often combined with recurrence interval). The information can be of qualitative or quantitative type. The colour

scheme utilized is of particular importance as the colours represent also the level of severity, i.e. a direct link to possible impact. This type of map is not requested by the flood directive but it is useful, e.g. for land use planning, awareness rising, emergency response.

3.4. Event maps

The analysis and the display of past events constitute a first approach to assess flood hazards. The proper delineation of areas affected by floods serves as a basis for further assessment and it provides excellent arguments for awareness building in flood risks and flood risk management. In general, the information is easy to understand and striking. The Event map can be used for awareness rising: simple and striking information, basis for follow-up flood hazard assessment, calibration of models etc., emergency management and planning tool (priority setting), if continuously updated.

3.5. Trans-boundary flood maps

Most of the European water resources are shared by two or more countries. European rivers, as for instance Rhine, Odra or Danube, often cross or (partially) form national borders. Flood mapping in these border areas is not an easy task due to various technical, legal, institutional and communicational problems. Trans-boundary flood hazard/risk mapping within a particular watershed or along the respective river can be done in bi- or multilateral co-operation. Examples of trans-boundary flood maps can be derived from the relevant activities and results of the various commissions of particular rivers or about shared projects.

3.6. Emergency maps

For crisis management and rescue services, information of importance are:

- Number of people to plan the scale of response and resources needed, evacuation route, safe havens/temporary refuge centres, hospital response plans
- Installations at risk that could lead to pollution or environmental damages as a result of flooding or for functions of importance for the society
- Transport disruption – temporary or semi-permanent short or long period – roads & rail
- Emergency maps may include a range of different information, such as:
- Flood extent maps linked to different flood warning trigger levels
- Locations where operational flood response is required (e.g., erection of temporary defences, closing of flood gates, etc.)
- Areas where evacuation is required / advised for given event severities,
- Properties of particular vulnerability (e.g., houses of people requiring assistance during evacuation)
- Evacuation routes and shelter areas

Different levels of map are likely to be required for public information and for use by emergency response authorities.

3.7. Insurance maps

Insurance maps can be simple maps showing how the probability of flooding varies taking into account all the flood risk reduction measures (including flood defences) i.e. the residual probability, or they can be more complex and illustrate the potential flood losses (i.e. the exposure of insured goods or risks). In the UK, the Environment Agency produces national postcode and property databases to give the insurance category for the land area where each property is located, and spatial data in the form of a map to show areas covered by different insurance categories.

4. DATA NEEDED FOR FLOOD HAZARD AND FLOOD RISK MAPS

4.1. Historical data

Historical data are very important for the risk assessment and the calibration of the models. Interesting data which can be collected are: records of the water level; pictures, paintings; historical reports; stories from witnesses, etc. Nowadays

this data can be received from the satellite images. In the databases of the satellites are saved all images and they can be used to determine historical floods.

4.2. Data for land use, infrastructure and related data

This data include information about the population, historical heritage, land uses, infrastructure (roads, electricity, water supply, etc.) and it can be found in different statistics and maps made by official institutions.

4.3. Geodesic data, digital elevation model (DEM)

The geodesic data can be collected by different methods – from existing maps, satellite images and laser scanning. The most accurate methods are satellite images and laser scanning.

Nowadays the most popular method is laser scanning because of its accuracy. The plane flies above the terrain and the scanner scans the land sending laser signal. The data need a postprocessing to remove the "noises". Using this information allows to create Digital elevation model (DEM).

All this data are very important base for the modelling of the floods, to prepare hydrological and hydraulic models.

4.4. Hydrological data

To determine hydrological parameters of the areas and the designed water amounts are used several methods. One of them is regionalization of the hydrological parameters of the area. The method consist in using the parameters of some area, where are available data about them, to determine the parameters in some similar area, where they are not available. For this purpose is needed information about the precipitations, landscape, hydrometric measurements, DEM.

The rainfall-runoff models are used to determine the hydrological parameters of the flood waves.

These parameters are the input information for hydraulic models.

4.5. Hydraulic data

Hydraulic models are used to describe the flood propagation in the river. The models can be 1-dimensional, 2-dimensional and combined.

1-dimensional models design the riverbed by cross-sections at some distance and the different works in the river must be pointed. Despite the rough simplification of physical processes, these models give quite acceptable results.

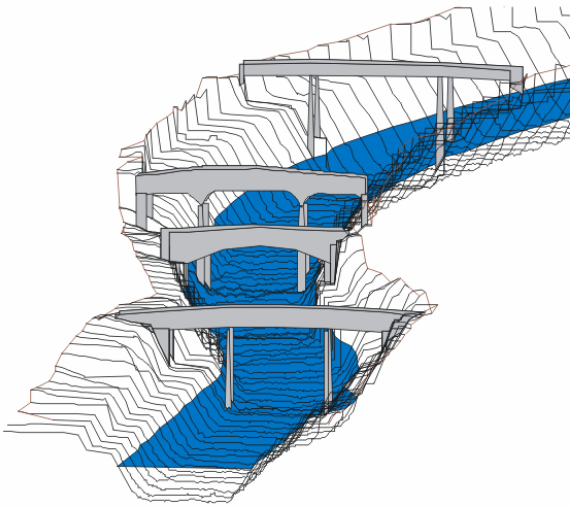

Figure 3. Determination of the geometry of riverbed by cross-sections

2-dimensional models usually are used for modelling the riverbanks. They are represented as net of elements, not lines. They are used for more sophisticated morphological conditions.

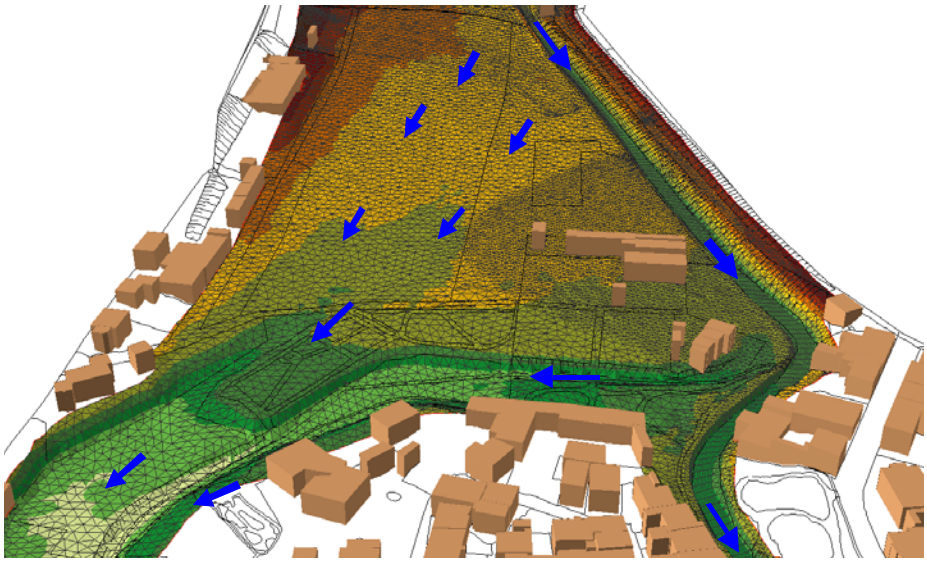

Figure 4 2-dimentional modelling

It is very often the using combined models – 1-dimentional for the riverbed and 2-dimentional for the riverbanks.

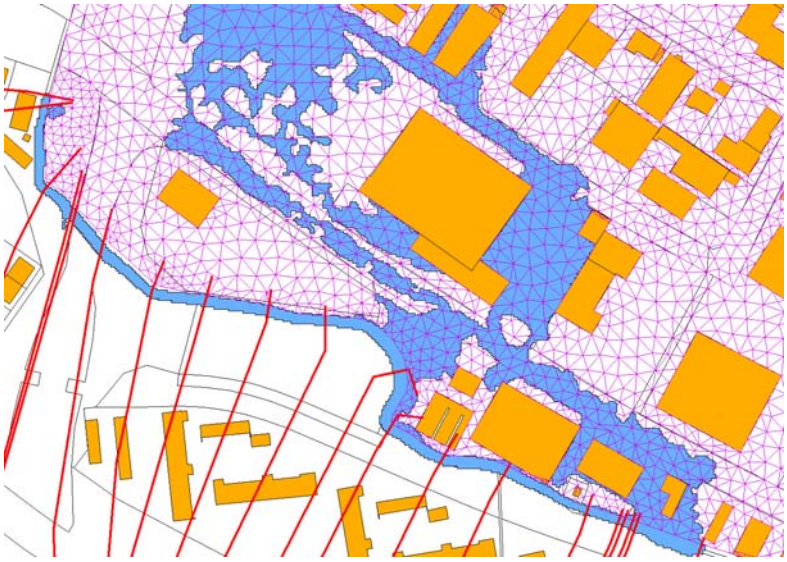

Figure 5. Combined modelling

4.6. Defining the damage and consequences

There are different methods to define the damage from floods. Their aim is to make dependence between water depth and flood damage. It is recommendable to be taken into account the duration of the flood too. It is easier to define the damage on the building or infrastructure. But it is very difficult to define the damage on cultural heritage or ecosystems because there are some consequences which are maybe impossible to define.

5. PROVISION OF THE RISK MAPS

There are no official instructions about the provision of the risk maps. Every Member State has to deal with this issue on its own.

Here is the example of Baden-Württemberg, Germany.

The maps are available online for all users. But the shown information is different according to the level of access.

The maps for the public can be zoomed to the scale of 1:5 000 and the boundaries and the house numbers are not shown.

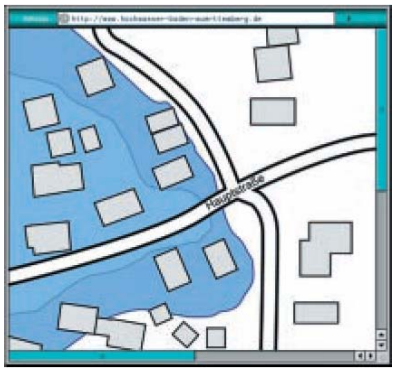

Figure 6. Provision of risk maps for the public

The maps for the local authorities show more information, but it is accessible only within the boundaries of the municipality.

Figure 7. Provision of risk maps for local authorities

The maps for professional department and regional associations give other information required for their tasks, e.g. orthophotos.

Figure 8. Provision of risk maps for professional department and regional associations

6. CONCLUSIONS

Flood maps are specific in their content (e.g. extent, depth, velocity, etc.) and purpose (flood risk management).

Flood maps are produced in cooperation with specialist from different fields – hydraulic engineers, economists, specialist from Civil Defence, specialists in cartography and GIS.

We have some first attempts to produce such maps, but we still have a lot to do. The lack of Bulgarian examples in this paper has to pay attention that we have to go a long way to reach the other Member States.

There is a lot of work to do in connection with this filed and the time is very limited by the requirements if the European flood risk directive.

References

1. DIRECTIVE 2007/60/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 23 October 2007 on the assessment and management of flood risks.
2. EXCIMAP, Handbook on good practices for flood mapping in Europe, 29-30 November 2007.
3. Schacze, J., Zeman, E., Marsalek, J., Flood Risk Management: Hazards, Vulnerability and Mitigation Measures, NATO Science Series 6-10 October 2004, Springer, 2006.
4. Fleming, G., et al., Flood Risk Management: Learning to Live with Rivers, Thomas Telford Publishing, 2002.
5. Committee of Flood Control Alternatives in the American River Basin, Water Science and Technology Board, Commission on Geosciences, Environment, and Resources National Research Council, Flood Risk Management and the American River basin, National Academy Press, 1995.
6. www.astra-project.org
7. Flood Risk Maps in Baden-Württemberg, Guidelines, Ministry of the Interior, Ministry of the Environment, Ministry of Commerce, Germany, 2009.
8. H. de Moel, J. van Alphen, J.C.J.H. Aerts, Flood maps in Europe – methods, availability and use, Natural hazards Earth System Sciences, 9, 289-301, 2009.