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Preliminary flood hazard and risk assessment in Western Athens metropolitan area

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Abstract The increase in urban population and the continuous pressure for cities' expansion along with the increase in urban flooding phenomena in Greece and worldwide, stress the need for enhancement of flood risk mitigation efforts. West Athens urban area, in Greece, experienced a significant population clustering since the 1950s leading, in some occasions, to a poorly-planned development, even in areas with imminent flood risk. An issue becomes apparent, taking into account the rich flooding record, the extended damages in property and infrastructure and the 76 flood victims during the last century in the area. In this work, flood hazard is assessed in 10 municipalities of West Athens, with the application of a GIS-based methodology that exploits catchment morphometric characteristics to delineate flood hazard zones. Historical flood events are reconstructed to provide better understanding of the flooding problem in the area. Finally flood hazard was studied in conjunction with vulnerability to estimate flood risk spatial distribution. The results showed that areas around Fleva and Eschatia torrent, especially Mpournazi, parts of Ilion and Kamatero and some parts of Peristeri presented the highest flood hazard and risk values. Additionally, moderate flood risk appeared in several mountain torrents in west parts of Petroupoli and Peristeri.

1 Introduction

The augmentation of cities' population has contributed to the increase of urban flood risk during the last decades worldwide. During the last years the efforts towards flood risk mitigation have been enhanced in EU and in Greece with numerous research projects, civil protection agencies' initiatives and improved legal framework. One of the most substantial legal binding instruments is the EU Directive 2007/60 which creates the obligation for completion of preliminary flood hazard assessments in river basins in all member states.

West part of Athens metropolitan area in Greece is not exception to this flood-prone regime, presenting a rich flooding record during the last century. Flood history data were collected based on numerous sources such as local and central government organizations, the General Secretariat of Civil Protection, and the press. Based on these data 14 flood events between 1900 and 2010 were identified (Table 1) inducing significant damages and killing 76 individuals. Historical events were reconstructed in spatial terms (Fig. 1) based on spatial information provided by the same sources, in order to identify areas with increased historical flood frequency.

In this work, preliminary flood hazard and risk assessments are carried out in West Athens metropolitan area, with the aid of a GIS-based methodology that uses morphometric characteristics of the catchment to predict the areas with high intrinsic flood hazard. The study area is an administrational entity in West Athens comprising of 10 municipalities. It consists of a significant portion of urban areas, situated in lowland, and a hilly part with ephemeral mountain torrents. Most of the torrents drain into Kifissos River which is the main drainage route in Athens basin, just outside the eastern limit of the study area. Kifissos River was not included in this study as the major parts of the main torrent are outside of the east border of the study area. The dense population and the augmented social, industrial and commercial activity in the area, lead to increased vulnerability in natural disasters.

Table 1. Historical floods in the study area between 1900 and 2010. Information is based on the GSCP (2007), local organization archives and press archives of the National Library's Digital Newspapers Collection (2010).

Flood data	Location	Torrent	Victims
26/10/1930	Sepolia	Kifissos	2
06/11/1961	Bournazi, Ilion, Ag. Fanourios, Mykoniatika	Fleva	40
Jan 1972	Western Athens	–	–
02/11/1977	Peristeri (mainly), Ilion, Antoupolis, Petroupolis	Fleva, Giorgiza, Vathi	25
28/10/1978	Aghioi Anargyroi	Kanapitseri	–
07/10/1980	Ilion, Petroupolis, Peristeri , Aghioi Anargyroi, Antoupolis	Giorgiza, Fleva, Vathi	–
27/10/1980	Ilion, Kamatero	Fleva, Euripidon	–
27/10/1986	Ilion, Peristeri	Fleva	–
12/11/1987	Petroupolis, Peristeri, Ano Liosia	Giorgiza	–
25/02/1988	Petroupolis, Ilion, Mpournazi	Fleva, Giorgiza, Chaidarorrema	–
09/12/1989	Aghioi Anargyroi	Kanapitseri	–
21/11/1994	Aghioi Anargyroi, Aigaleo	Kifissos, Podoniftis, Chaidaror-	9
27/01/1996	Western Athens	–	–
08/07/2002	Aigaleo, Koridallos	Kifissos	–

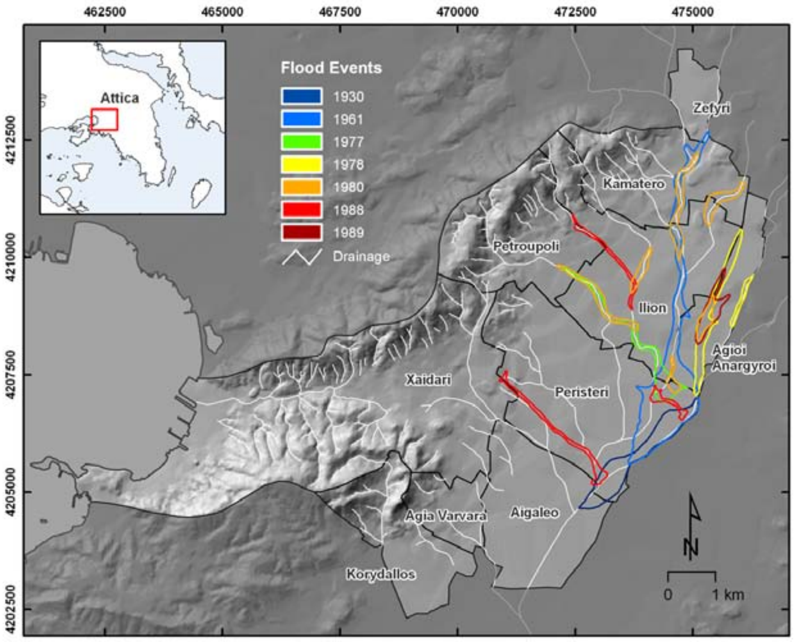

Fig. 1: Location map of the study area. Municipalities of West Athens under examination, drainage network and extent of past flooding phenomena.

2 Data and methods

A GIS-based methodology was used for hazard assessment, exploiting morhometric characteristics of the catchments under study. The basic concept of the methodology was the compilation of a flood hazard map based on the peak discharge values derived from multiple instantaneous unit hydrographs across the catchments under study. Unitary hydrographs were compiled along the drainage network in numerous locations assumed to be the outlets of theoretical sub-catchments. Hydrographs were compiled with the use of ArcHydro Model (Maidment 2002) and the Time-Area method (Clark 1945). Time-Area histograms for every sub-catchment were converted to hydrographs by applying a 1 mm uniform rainfall. Finally, calculated peak flow rate values of these hydrographs highlighted locations where intrinsic morphometric parameters of the basin tend to produce higher peak flows, which in turn indicate flood hazard potential. The whole procedure was carried out in GIS and a grid format is used to represent the spatial distribution of values of all variables involved. Geological data used were based on geological maps (Gaitanakis 1982, Katsikatsos et al. 1986, Papanikolaou et al. 2002) and additional detailed field mapping, locally in 1:5.000 scale (Gouliotis 2002). Land use data were based on CORINE maps (EEA 2000) and topographic maps of 1:5000 scale from the Hellenic Military Geographic Service (HMGS). Geology and land use were used to define the concentration time in every sub-catchment, a parameter necessary for hydrograph derivation. A summary of the methodology is shown in figure 2. A detailed description of the methodology is available from Diakakis (2010).

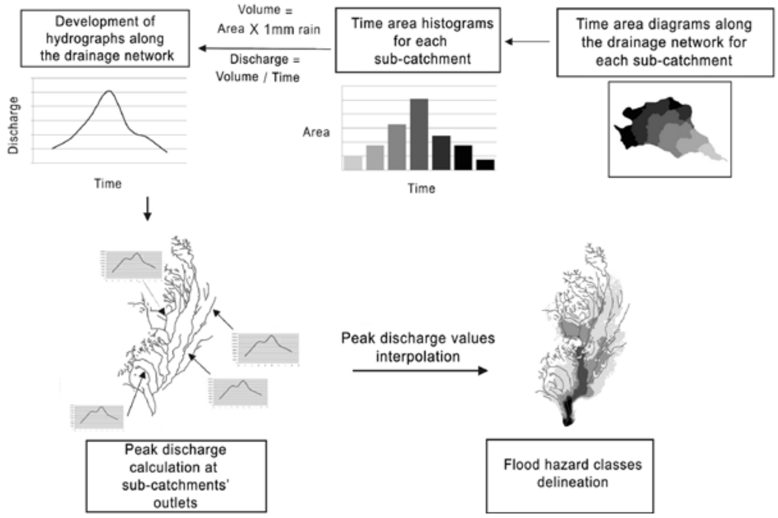

Fig. 2: Basic steps of the methodology

Subsequently, vulnerability was determined, by categorizing the study area into four classes according to the significance of elements present, and taking into consideration the impact from possible flood damage. Data on infrastructure, housing, road network, public facilities and critical services were provided by the Development Association of West Athens (ASDA). Detailed description of this classification is illustrated in Table 2, while a sample of vulnerability distribution within a selected part of the study area is shown in figure 3.

Table 2. Categorizing the study area into four classes according to the significance in terms of vulnerability of elements and infrastructure at risk.

Vulnerability class	Elements distributed to each class
Very high	Town halls, Police & Fire brigade stations, Hospitals / Clinics, Schools
High	Churches, Public Services, Ministries
Moderate	Houses, Exhibition centers , Theatres & Cinemas, Camps, Banks
Low	Parks, Sports facilities, Cemeteries, Parking lots

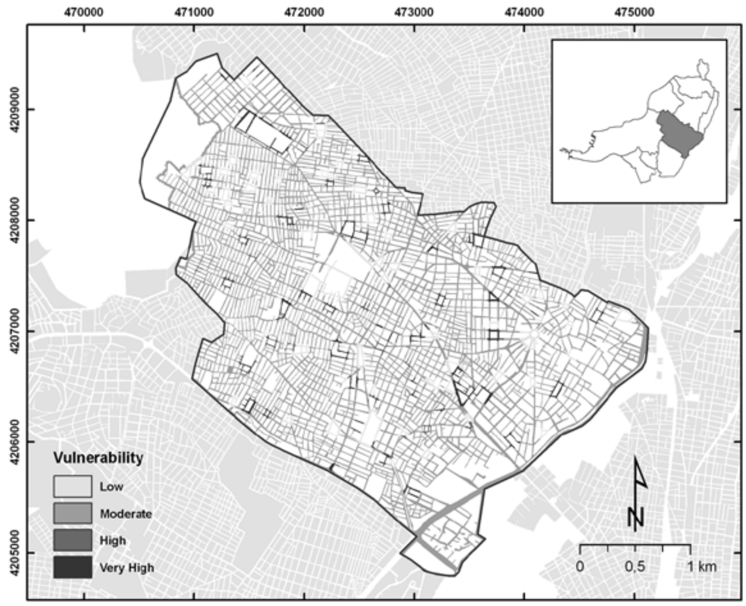

Fig. 3: Sample map of a part of the study area, showing different values of vulnerability.

Hazard and vulnerability maps were transformed in a grid format that allowed simple mathematical functions between them in a GIS environment. In this context, “Vulnerability grid” was multiplied on a cell to cell basis with “Hazard grid”. Risk was determined as a function of hazard and vulnerability with these two parameters operating as amplifying factors to the risk level, according to the following equation:

$$R = H \times V$$

Where R is risk, H is hazard and V is vulnerability. The final risk map was the result of this multiplication in a grid format and categorized in five classes (Very high, High, Moderate, Low and Very Low).

3 Results and discussion

Reconstruction of historical events highlighted the areas where there were significant flooding problems in the past. As far as the hazard distribution is concerned the analysis showed that higher values are mainly observed around Fleva torrent in the areas of Ilion, Mpournazi and parts of Ilion and Peristeri. In addition, high hazard values appear along Eschatia torrent mainly across Kamatero (Fig. 4). Comparison of hazard distribution with flood reconstruction based on historical evidence presented a good correlation.

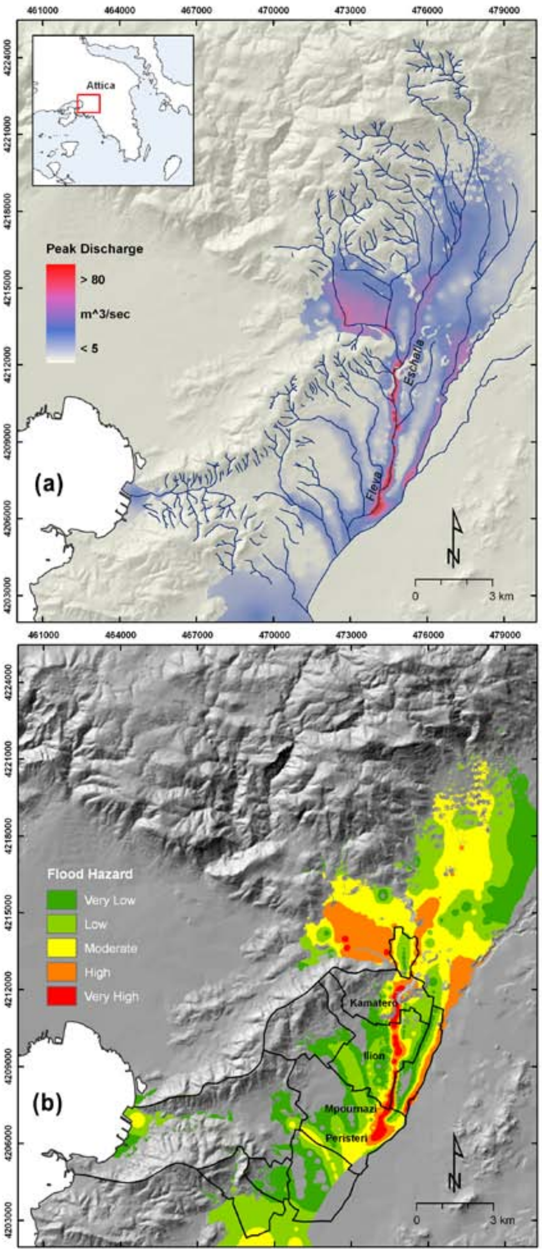

Fig. 4: (a) Flood hazard map of the study area in absolute peak discharge measures (m^3/sec) and **(b)** in relative terms as delineated hazard zones.

Subsequently, hazard was multiplied with vulnerability resulting in a preliminary risk map (Fig. 5).

Based on risk distribution maps one can identify the locations around Fleva torrent especially Mpournazi, Ilion, Kamatero and parts of Peristeri and Agioi Anargyroi as the ones with the major flooding issues. Moderate flood risk appears at the border between Peristeri and Aigaleo while lower risk is presented at some parts of Petroupoli and Ilion along ephemeral torrents draining from the Aigaleo hill.

Although this approach does not give any quantitative expression hazard and risk, it certainly highlights and prioritizes the locations where actions have to be taken to mitigate risk. One of the advantages of the approach is its ability to produce results in short time and with low data and cost requirements, as it can function with commonly available inputs such as land use, geology and topography. In this sense the method fulfils the requirements of a preliminary flood risk assessment in the context of the EU and Greek legal framework and identifies the areas where further study (e.g. 1-D modelling) is required.

Moreover, in this study, it is shown that the use of historical data combined with the use of a method based in geomorphology could be a useful and reliable tool that contributes to a better understanding of the flooding issues.

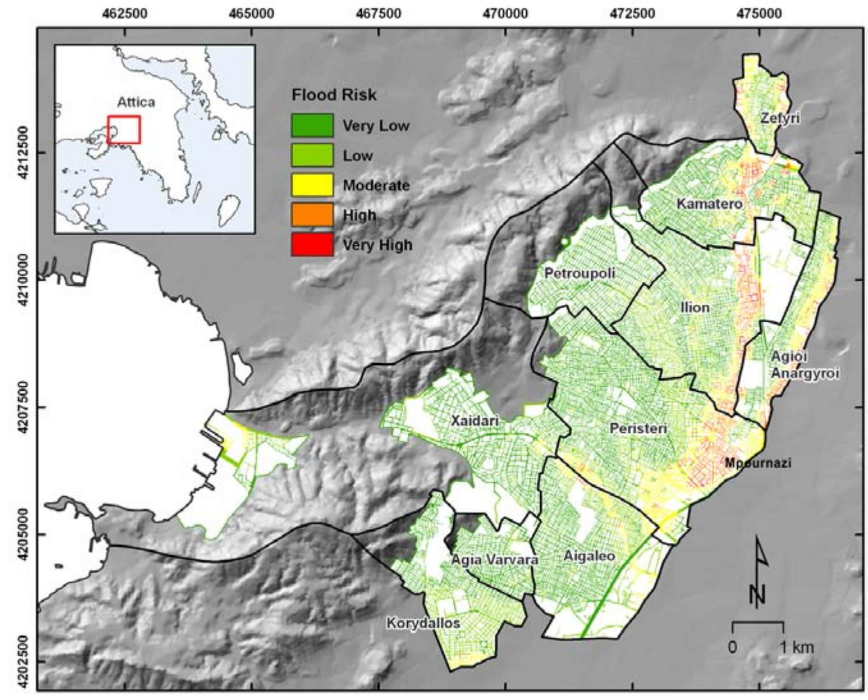

Fig. 5: Flood risk map of the study area. Higher risk values appear in Mpournazi, Ilion, Peristeri and Kamatero mainly in areas around Fleva torrent.

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