15th International Congress of the Geological Society of Greece
Athens, 22-24 May, 2019 | Harokopio University of Athens, Greece
Bulletin of the Geological Society of Greece, Sp. Pub. **7** Ext. Abs. GSG2019-141

Floodplain Mapping using Hydraulic Simulation Hec-RAS in G.I.S: A case study for Rafina basin (Attica, Greece) based on February 2013 storm event.

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Introduction

Floodplain mapping is a basic tool for flood risk assessment (Correia et al., 1998). The coupling of hydraulic modeling Hec-RAS (Hydrological Engineering Center's River Analysis System) and G.I.S (Geographical Information System) has become a very effective tool in the field of flood risk prediction and management. Mapping the floodplain zones of a stream or a river is an important exercise related to both land-planning and river basin management (Yang et al., 2006).

The drainage basin of Rafina was mainly an agricultural region until the decade of 80s. According to the demographic data of the Greek Statistical Service (Hellenic Statistical Authority, 2015), population has increased about 3.5 times the last 30 years. Extreme fire events, roads constructions and uncontrolled building construction during that period of time were the triggering point of the following high rate urbanization. Flood history data has pointed out that flood events frequency increased during the above period. The conversion of agricultural and forest land use to urban and mixed-urban land use, strengthened the vulnerability of the drainage basin.

Information gathered from governmental organizations, emergency agencies, the press and field observations along with geologic, geomorphologic evidence, land use and hydraulic simulation by using Hec-Ras along the final 4km of the main stream, were stored, structured and analyzed in GIS platform, resulting ultimately flood plains delineation. A severe storm event on 22/02/2013 was taken as a case for the modeling framework.

Study Area

The study area is situated in East Attica approximately 15km east of Athens (Greece), consisting of a small catchment drained by Megalo Rema torrent. In terms of geomorphology, Megalo Rema basin (area 115km^2) consists of Pedeli mountain (920m a.s.l.) on the north and Ymmitos mountain (620m a.s.l.) on the northwest, draining into a low lying south part (max elevation 300m). The slope range is between 0^o – 44.4^o and the mean slope is 6.3^o. The main channel of M.Rema torrent is a sixth-order stream (Strahler) which reaches the sea near to the Port of Rafina, to south Evoikos Golf, passing through a small valley where settlements of the municipalities of Geraka, Pallini, Peania and Rafina are situated. The land use is urban-mixed, urban and agricultural. The catchment is a small, flash flood basin drained by ephemeral watersources with an asymmetric drainage network (Fig.1A). The research of the flood history gives an Average Frequency of floods events 1Flood Event/2.7yrs during the last 27 years (Andreou, 2016).

Methodology

In this study delineated floodplain areas along the final 4km of the main stream M.Rema, by using ArcGIS version 10.0, Hec-GeoRas extension version 5 and hydraulic simulation Hec-GeoRas version 4.1. The accuracy of the results is defined by the geometric input data (Casas et al., 2006), in order to ensure the model precision we used a DEM (.dwg file) 1:500 scale. Two hundred cross-sections cutlines were created by HEC GeoRas, 1 cross-section cutline /20m, as input geometric data for the hydraulic simulation in HEC-RAS model (Fig.1B). Steady flow analysis is applied to manage the calculation of water surface profiles.

The steps that were followed between ArcGIS, Hec-GeoRas and Hec-Ras are described in Fig.2.

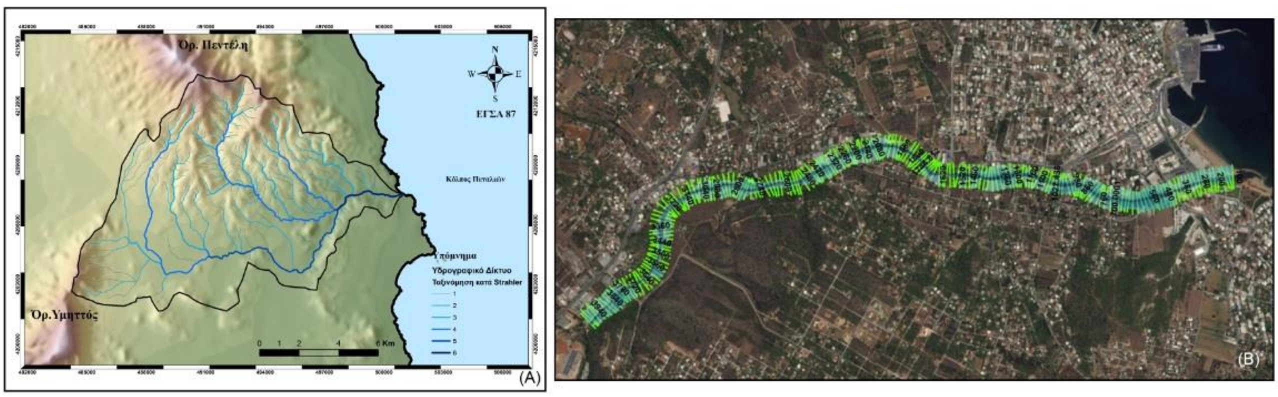

Figure 1: (A) Dem-Drainage Network, (B) Cross-sections cutlines along the final 4km of the main channel of M.Rema torrent.

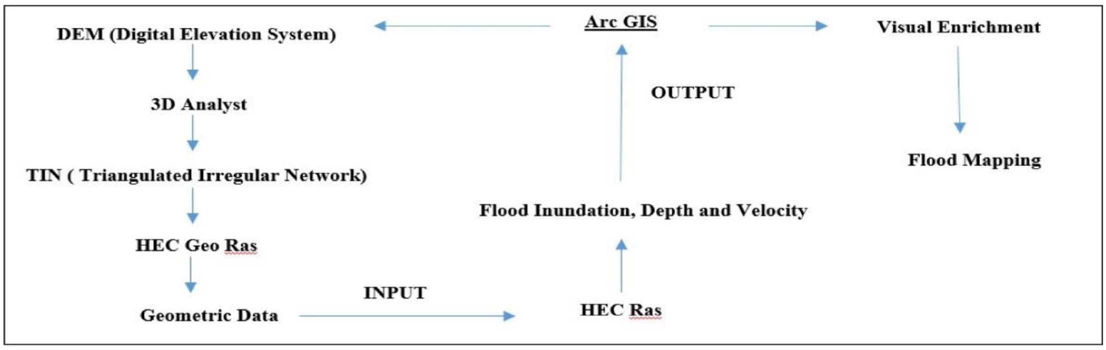

Figure 2: Steps in model design, using ArcGIS (geometric data-land use data) as INPUT data to HEC-Ras model and visualization the OUTPUT data by using GeoRAS extension (RAS Mapping) in ArcGIS.

Land-use data were obtained by Corine 2000 (CLC 2000), Ilots 2012(CLC 2012) land cover and field observation. Manning's n values were derived from the manual of the hydraulic model (HEC-Ras Hydraulic Reference Manual, 2010). The flood plain delineation exercises applied in the study were repeated for three discharges values: (A) discharge value of the storm event on 22/02/2013, Q_1=150m^3/s, (B) discharge value for return period 25 years Q_2=300m^3/s (Lazaridis – Nalmpantis, 2004), (C) discharge value for return period 50 years Q_3=600m^3/s (Tsakiris, 2007) (Fig.3).

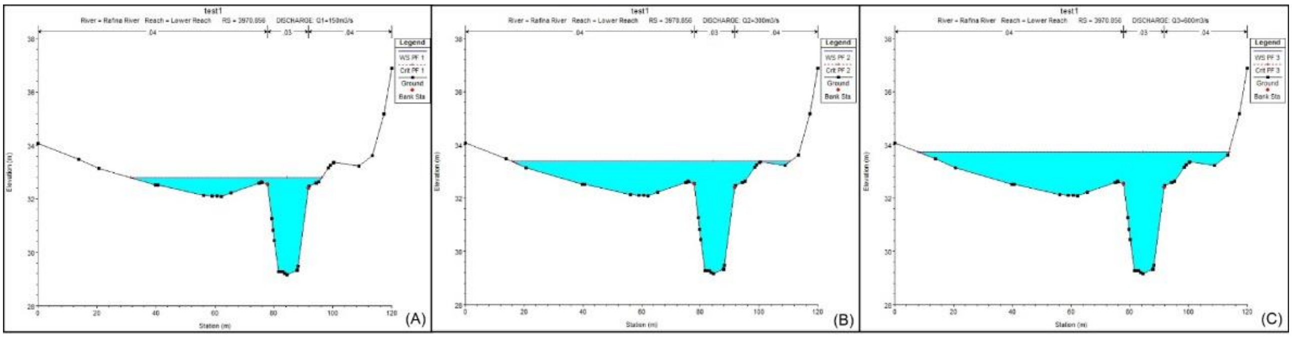

Figure 3: Cross section of 3970m, (A) profile1 Q_1=150m^3/s, (B) profile1 Q_2=300m^3/s, (C) profile1 Q_2=600m^3/s

Results

The results of the hydraulic simulation (HEC-RAS) for Q_1 profile fully correspond to the recorded construction's damages of the storm event on 22/02/2013, 43% of the 200 cross-sections cutlines are located in floodplain zones. The percentage of the cross-sections cutlines that are located in floodplain zones is 83% and 97% for Q_2 and Q_3 correspondingly.

High vulnerability areas are bounded by cross section ranges 4000m.-3700m. and 1000m.-100m. for Q_1 profile, 4000m. – 3680m., 3460m.-3260m., 3120m.-1920m., 1760m.-1280m. and 1220m.-0m for Q_2 profile. As concerns Q_3 profile the evaluation is that the whole distance (4km) presents high rate of vulnerability.

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