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Hydrological and hydraulic modelling for a severe flood event in Sperchios River Basin

Bournas A.*, Feloni E., Bertsioy M., Baltas E.

Department of Water Resources and Environmental Engineering, School of Civil Engineering, National Technical University of Athens, 5 Iroon Polytechniou, 157 80, Athens, Greece; +302107722357;

*corresponding author: e-mail: abournas@chi.civil.ntua.gr

Abstract

A combined hydrological and hydraulic analysis is presented for an extreme flood event occurred on February 6, 2012 in Sperchios River Basin, located in Central Greece. This event caused the river's overflow and, consequently, several damages to infrastructure and agricultural land. Sperchios River Basin is a case of ungauged basin and only rainfall measurements of fine temporal scale are available. The hydrological analysis was performed with the aid of the Hydrologic Modeling System (HEC-HMS) to incorporate and combine different methods concerning the rainfall-runoff transformation, the hydrological losses, the river routing and the baseflow recession, and finally to generate the flood hydrograph. The hydrological analysis output was then used in the River Analysis System (HEC-RAS), which has the ability to model unsteady flow through a river channel network and produces the water profiles, velocity and inundation maps of the flood plain. The implementation of this integrated model for historic flood events in such ungauged basins is useful for reducing the uncertainty and developing robust flood forecasting and early warning systems in order to reduce life casualties and mitigate losses due to flooding.

Keywords: rainfall-runoff, inundation mapping, flood, Sperchios, HEC-HMS, HEC-RAS

1. Introduction

The study of historic floods is important for evaluating the flood characteristics of areas, mainly the extend and the depth of flood, in order to determine proper flood mitigation policies. Current studies couple hydrologic and two-dimensional (2D) numerical simulation models to perform the needed flood simulations (e.g., Thakur et al. 2017; Rollason et al., 2018), since incorporating a 2D scheme provides better results and proves to be an important tool for understanding flood events when high uncertainty is involved due to data scarcity (Bhandari et al. 2017; Quirogaa et al. 2016).

In this research work, the flood event occured on February 6, 2012 in Sperchios River Basin area (Central Greece) was studied. The HEC-HMS was used to estimate the flood hydrograph while the HEC-RAS 2D model was used to nummerically simulate the flow path across the Sperchios valley. Finally, different scenarios regarding flood-proofing technical works were performed to evaluate the impact on the flood extend reduction, as mitigation policy.

2. Study Area and Datasets

The Sperchios River Basin lies within the Evritania and Fthiotida regions of Central Greece. Its springs are located at Mount Timfristos (altitude 2.327 m) and is surrounded by Mount Orthys and Mount Vardousia, Oiti and Kallidromo, before it discharges in the Maliakos Gulf. The total area of the river basin in about 1656 km^2 with a mean altitude of 644 m and is characterized by a mountainous region with high slopes and a flat region, the Sperchios valley, where mainly agricultural activity is found. The geomorphological characteristics in combination with the rainfall regime are the main cause of severe flooding. Sperchios River alters from a mountainous steamy river into a lowland river, as shown in Figure 1. The area where the analysis was performed lies between the Leianokladi and Komma settlements and is generally more prone to flooding.

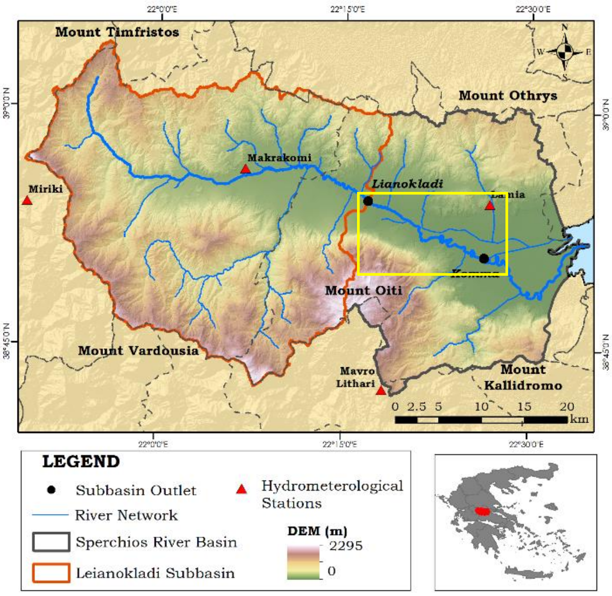

Figure 1. Sperchios River basin alongside the hydraulic simulation area (rectangle).

For the hydrological simulation of the basin, rainfall measurements of high resolution temporal scale (10min) were analyzed for four stations (Makrakomi, Lamia, Mavro Lithari and Miriki). These stations belong to the NOANN station network (Lagouvardos et al., 2017).

The digital elevation model (DEM) used for the hydraulic simulations was provided by the National Cadaster & Mapping Agency S.A. and it features a 5x5m grid elevation dataset. For the hydraulic analysis, the Corine Land Cover 2012 (CLC, 2012) was used to determine the land characteristics, as well as, the Manning roughness coefficient, that was estimated according to the global literature (e.g., Arcement and Schneider, 1989; Barnes, 1967).

3. Results

The analysis of the flood event initially includes the determination of the flood hydrograph up to Leianokladi bridge (Fig. 1). For the rainfall-runoff transformation, the Snyder Synthetic hydrograph (Snyder, 1938) was used, while the precipitation losses were estimated using the exponential equation method available in HEC-HMS. The flood hydrograph (Fig. 2) was used as input for the HEC-RAS 2D model along with the DEM and the manning roughness coefficient dataset, which was estimated according to the land cover of the study area. The inundation map resulted in satisfactory results as the flood extent seen from historical photographs and airborne imaginary is about the same. This flood covered a large portion of the agriculture activity while no settlement was effected.

The hydraulic analysis of the event was also performed for various flood-proofing scenarios that aim to the reduction of the peak flow, in order to evaluate the impact on the flood extend. The inundation maps for two indicative scenarios, for a 20% and 30% peak flow reduction, against the base scenario (red color) are shown in Figure 3. In the first scenario a 47% reduction of the flood extend was calculated, while in the second case a total of 71% reduction was achieved. Finally, it is observed that the flood extend does not follow a linear relationship with the peak flow, since a 10% reduction of the peak flow can reach a total of 24% reduction of the flood extend.

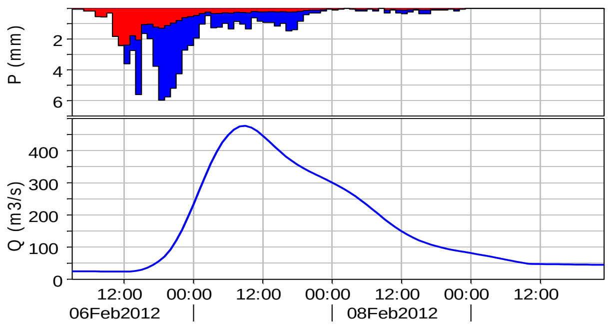

Figure 2. Flood hydrograph of the 06-Feb-2012 event at Lianokladi Bridge.

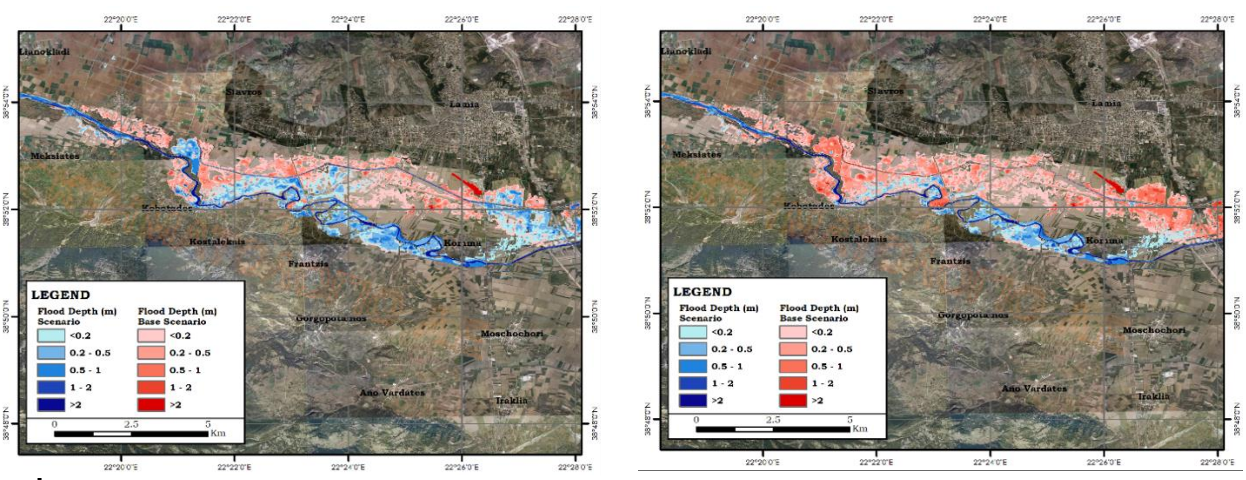

Figure 3. Inundation Map of the study area. Left, 20% peak flow reduction. Right 30% peak flow reduction.

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