EXTENDED ABSTRACT

Introduction

Floods are a natural phenomenon that is often characterized as extreme, due to the serious material damage and human losses. A flood can simply be defined as the temporary covering by water of land not normally covered by water. Floods are normally caused by climatic processes, while their evolution depends mainly on geomorphologic factors, such as soil stability and permeability, vegetation cover, as well as the geometrical characteristics of the river basin.

Scope

In this postgraduate thesis, entitled as, "Implementation of a methodological framework for mapping flood inundation in Sarantapotamos river basin", the process of hydrological river basin simulation, the hydraulic simulation of a stream section and finally the export of piezometric flood depth maps and flood depth polygon maps are examined.

The study was accomplished through the use of the software developed by the Hydrologic Engineering Center of the U.S. Army Corps of Engineers, specifically the hydrological model HEC-HMS and hydraulic model HEC-RAS. The first, applied to simulate rain-runoff processes in river basins, while the second allows the one-dimensional analysis and simulation of natural water courses or artificial systems. The preprocessing of the data obtained with the geographical information system ArcGis and specifically with ArcGis extensions, HEC-GeoHMS and HEC-GeoRAS.

Thesis outline

The thesis is structured in chapters as follows:

Chapter 1 Introduction

- Floods-Generally.
- Current conditions in Greece.
- The institutional framework for floods.
- Hydrologic models- HEC-HMS.
- Thesis scope and brief description of the methodology followed.

Chapter 2 Case study

- Presentation of the case study.
- Geographical information.
- Digital elevation model, slopes, land use map, soil type map.

Chapter 3 Hydrologic simulation of river basin

- Data preprocessing, through the use of HEC-GeoHMS, for the determination of basin topology and hydrographic network and finally the computation of topographical and hydrological characteristics.
- Hydrologic simulation, through the use of HEC-HMS, for the computation of design floods for several return periods and observed rainfall event.
- Scientific background of the methodology followed.
- Hydrologic simulation results.

Chapter 4 Hydraulic simulation of Sarantapotamos river

- Creation of geometry file and determination of river geometry through the use of HEC-GeoRAS.
- Import of hydrologic file to HEC-RAS, from the hydrologic model HEC-HMS (peak outflows).
- Hydraulic open channel flow simulation in steady flow conditions, through the use of HEC-RAS, for the computation of piezometric surface and energy gradients.
- Scientific background of the methodology followed.
- Hydraulic simulation results.
- Exportation of simulation results to HEC-GeoRAS for the digital mapping of water surface and floodplain delineation for each return period and the observed rain event.
- Water surface maps for each return period and the observed rainfall event.
- Floodplain delineation maps for each return period and the observed rainfall event.

Chapter 5 Application through the use of HEC with observed rainfall event.

- Conversion of point precipitation to surface precipitation through the Thiessen polygon method.
- Hydrologic simulation of river basin, through the use of HEC-HMS.
- Hydrologic simulation results.
- Hydraulic simulation of Sarantapotamos river through the use of HEC-RAS.
- Hydraulic simulation results.

Chapter 6 Conclusions

- Evaluation of the study and recommendations for further research.

Case study

The case study of the developed methodology is a part of Sarantapotamos river basin, in Eleysina, Greece, covering an area of 200 km^2. For this region, the collected raw data consisted of the digital elevation model, as well as the land use and soil type maps. Due to lack of rainfall data, for the hydrologic inputs, we initially used reliable rainfall data in the estimation of rainfall intensity curves, as adapted to data from adjacent basins. The hydraulic simulation is run on 20 km along Sarantapotamos river in steady flow analysis.

Hydrologic simulation

The hydrologic simulation was designed and run through the use of HEC-HMS, with the collaboration of HEC-GeoHMS, which is a hydrologic add-in tool in the ArcGis platform.

The input files required, are the basin model file, which is constructed in HEC-GeoHMS software, and the meteorologic model file. Initially, we selected the methods for the computation of rainfall losses and direct runoff. Specifically, the SCS method was applied for the computation of rainfall losses and the user specified unit hydrograph (a variation of the British Hydrological Institute method) was applied for the calculation of the direct runoff. The channel flow routing is used for specific cases by lag time and the baseflow component is omitted on purpose, due to lack of data.

The meteorologic model file consists of rainfall events which derived from the estimated rainfall intensity curves, corresponding to the return periods T=20 yrs, T=100 yrs, T=1000 yrs, applied in each subbasin of the case study. The simulation was run for this design storms as well as, for the observed rainfall event. The output of the procedure is a package of flood hydrographs for each subbasin and each return period (like the one shown in fig.1).

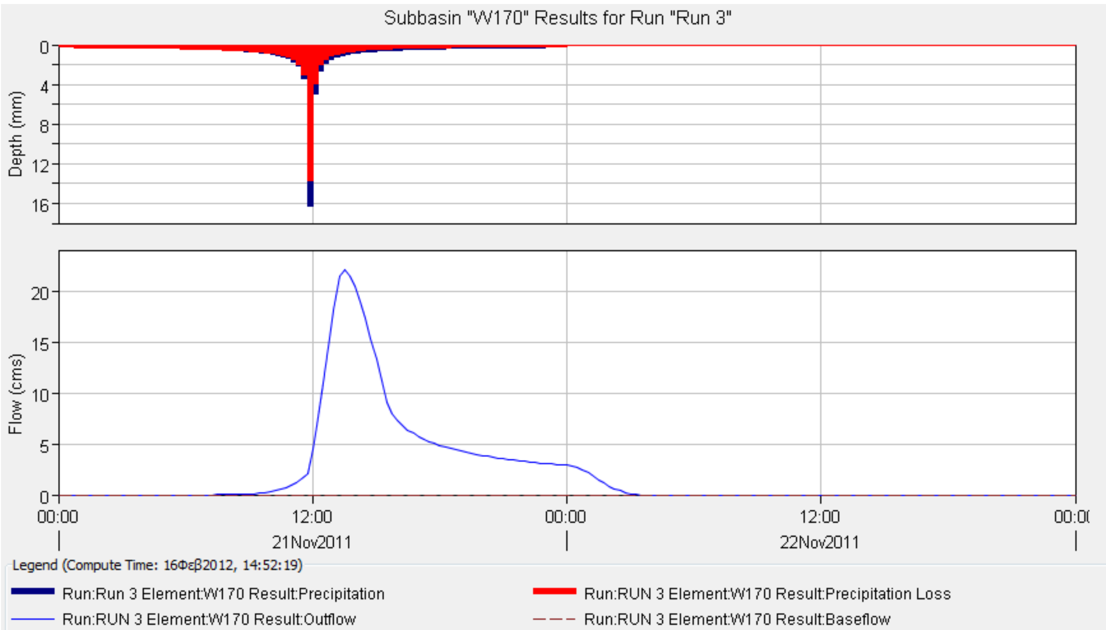


Figure 1. Rainfall hyetograph and direct runoff hydrograph for a 24-hour rainfall event corresponding to 20-years return period to an upstream river basin.

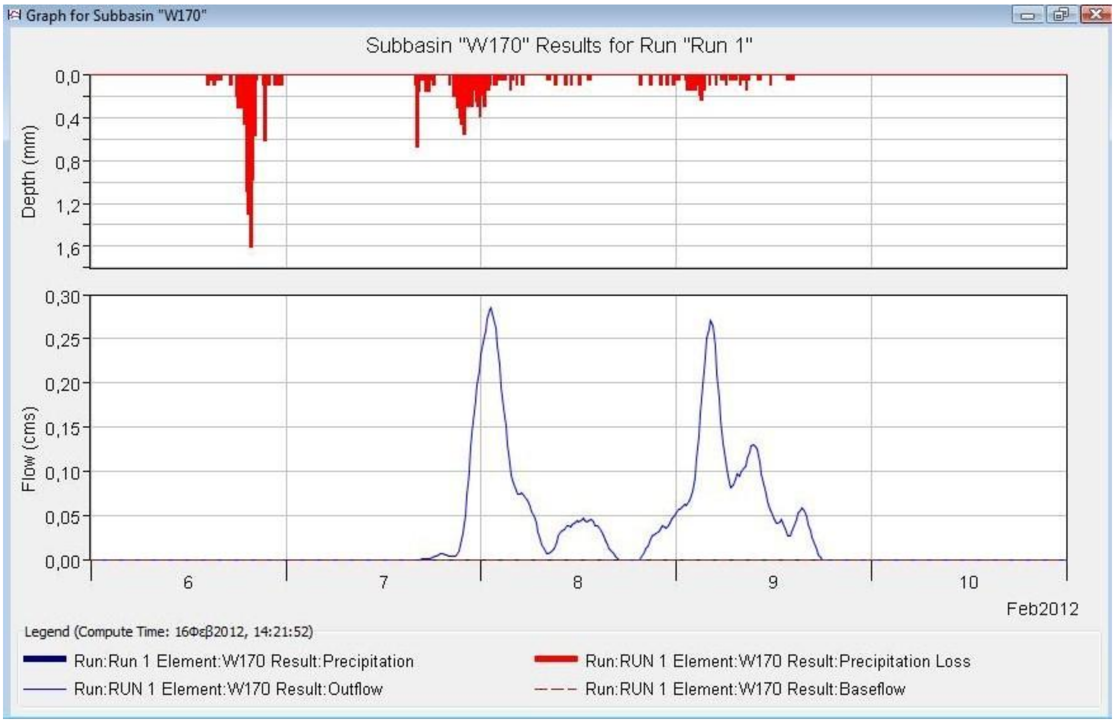


Figure 2. Rainfall hyetograph and direct runoff hydrograph for an observed rainfall event (06/02/12-10/02/12) to an upstream river basin.

Hydraulic simulation

The hydraulic simulation of 20 km along Sarantapotamos river was designed and run for the selected return periods through the use of HEC-RAS, with the collaboration of HEC GeoRAS, an add-in to ArcGis.

Firstly, a geometric file is created in HEC GeoRAS, which includes the basic layers of the geometry of river, i.e. stream centreline, banks, cross sections etc. After the accomplishment of the first step, the geometric file is imported in HEC-RAS program and the hydrologic file is created. This file includes the peak discharges as they are computed in HEC-HMS. The river was simulated in steady flow conditions and the relevant boundary conditions, as set up according to the data.

The whole computational procedure is based on the resolution of the energy balance equation between successive river cross-sections. Particularly, the calculations result in the determination of the piezometric depth, the mean kinetic energy and the energy gradient for every cross-section. In the following chart is presented a river cross section to a downstream position for a 20 year flood, 100 year flood and 1000 year flood.

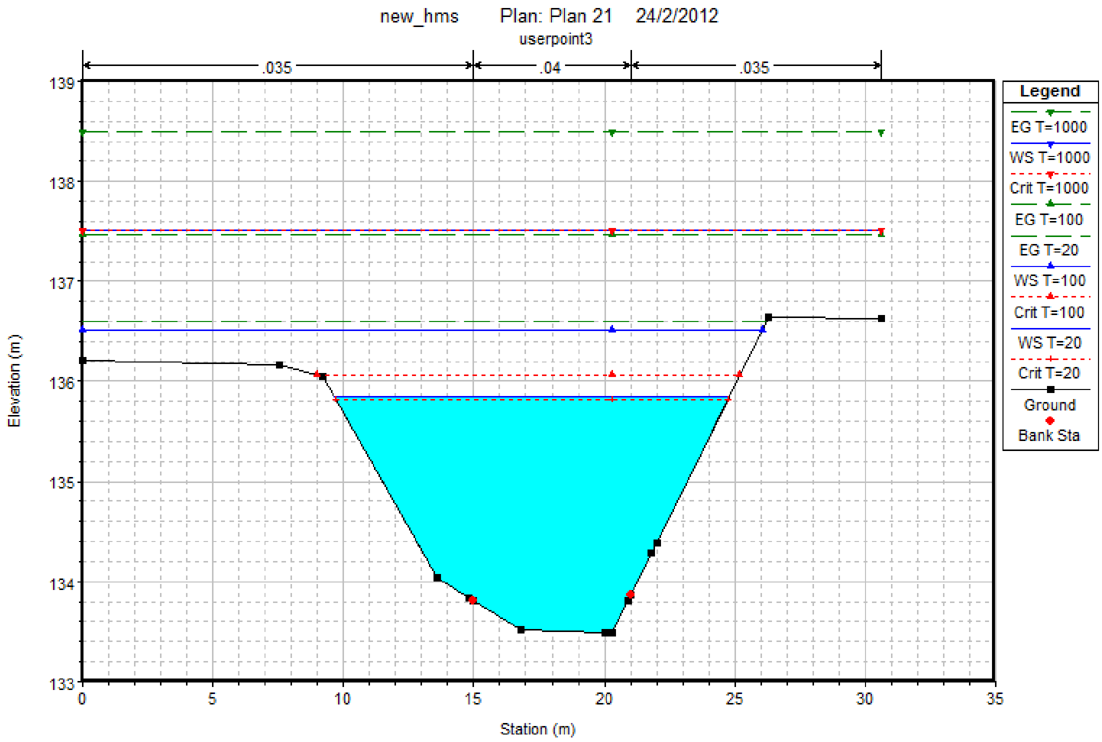


Chart 1. A downstream river cross section for flood events for the three return periods (20 years, 100 years, 1000 years)

Digital mapping

The results of hydrologic and hydraulic simulation are imported in HEC GeoRAS and they include all the necessary information for the creation of flood maps.

The software compares the grid cell values of the digital elevation model (i.e. topographical elevations) with the corresponding values of piezometric surface (i.e. water surface elevations). Consequently, the software constructs a three dimensional model of water surface profiles from the river cross section and the piezometric depth on each cross section. In points where the elevation of the piezometric surface is higher than the ground elevation, the difference between two heights is calculated, which represents the corresponding water depth at the position. The output product is a new grid surface, which depicts the water depths in the whole area of the river basin. A floodplain inundation map for a 100 year flood event is presented in the end of this document.

The comparison between the inundated areas between the three different flood events leads to the conclusion that there is a little correlation between the increase in peak discharge flows with the corresponding increase in the floodplain area. Listed in a comparative chart, are the areas of floodplain for these cases.

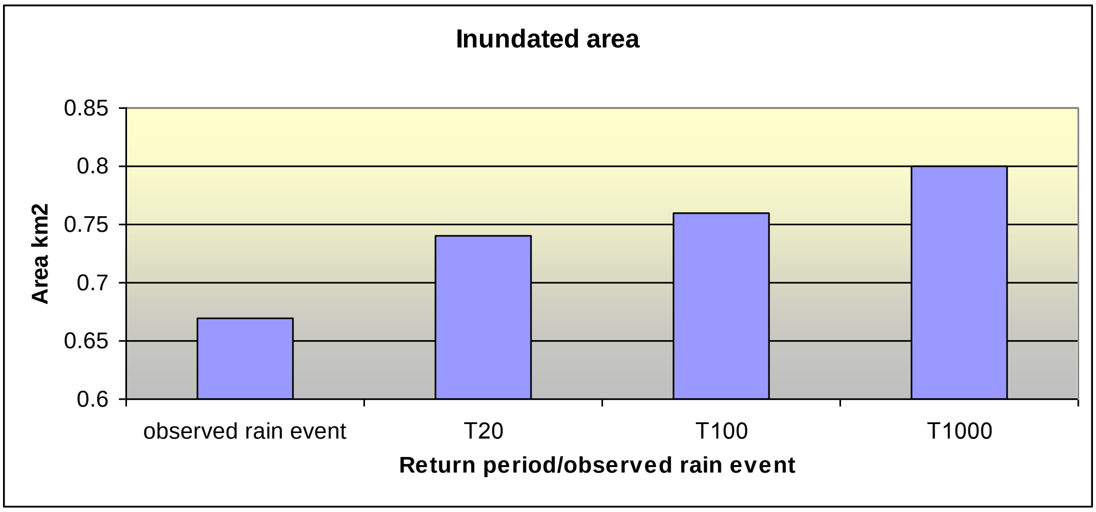


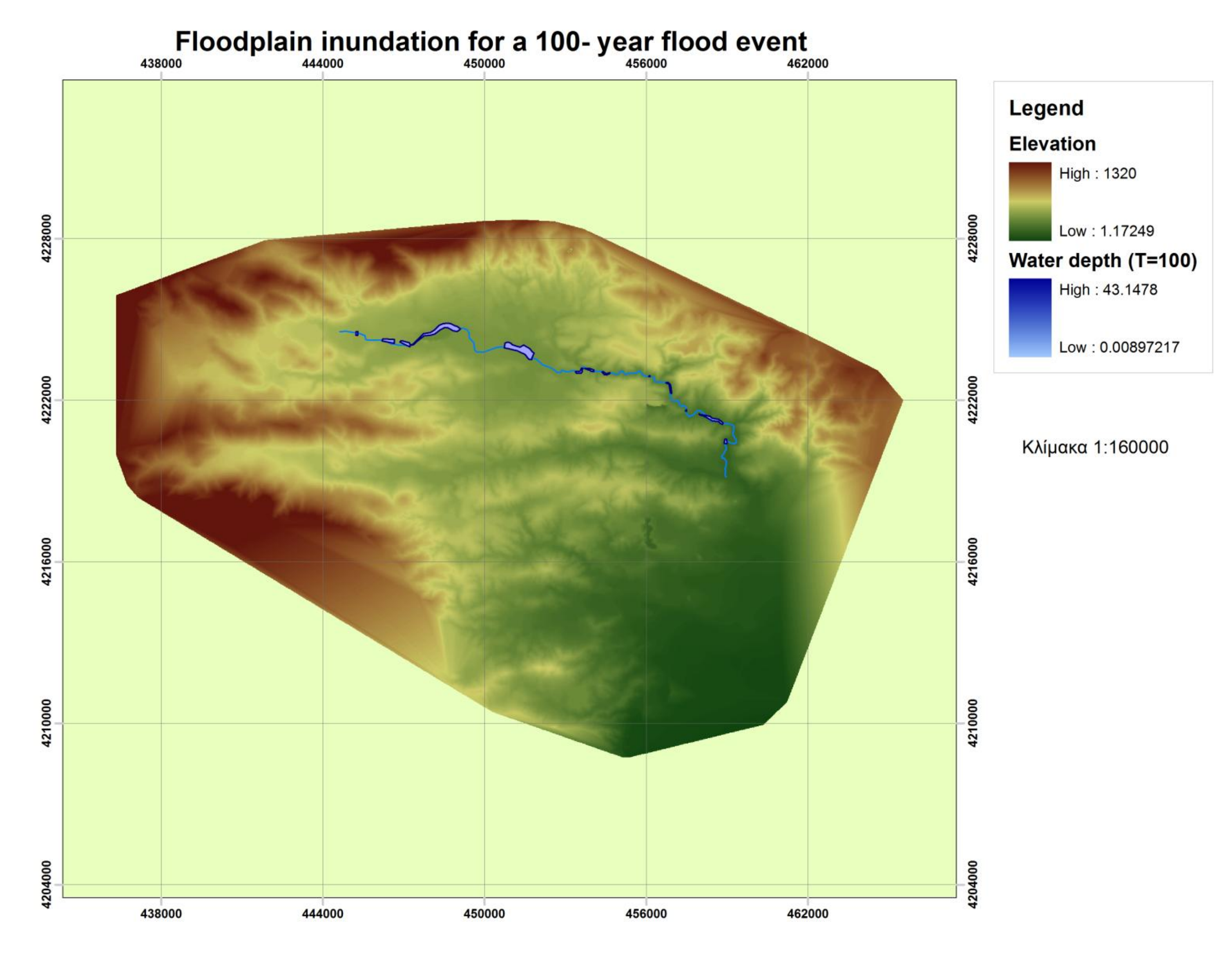
Chart 2. Comparative presentation of inundated areas.

Evaluation of the study

Floods are among the most crucial problems in the field of natural disasters management. The floodplain delineation of a basin for several flood events is of vital importance, specifically in regions where human activities, like agriculture, farming and industry flourish.

The flood hazard mapping that addresses this thesis is an essential part of the Directive 2007/60/EC on the management of flood risk. The integrated approach to the evaluation of flood affected by the flood risk mapping, which describe the adverse flood effects.

Another plan of evaluation of this thesis could be the examination of the other methods for computation of rainfall losses and direct runoff which provides the HEC-HMS program.



Map 1.Floodplain inundation for a 100 year flood event