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# A Web-Geographical Information System for Real Time Monitoring of Arachthos River, Greece

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Abstract: The scope of this work is to present a Web-GIS that will monitor the broader area of Arachthos River in order to serve as an online mechanism for early warning and mapping of flood events. It describes briefly the main technologies for developing a web-based GIS system i.e. mapping technologies, developing databases and web applications. The advent of client-side web mapping has provided all the necessary tools to develop platforms for creating Web based Geographical Information Systems (Web-GIS). The information system combines data deriving from different sources such meteorological, geographical and water level data that are visualizing within the Web-GIS platform. The design and operation of the system aims to enhance the local government and relative stakeholders' knowledge in order to improve decision making processes and efficient crisis management, in case of a flood event; while, another scope is also to keep the general public informed for the case of emergency situation.

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#### 1. INTRODUCTION

Climate change issues are now becoming more urgent than ever concerning not only academics but also policy decision makers in terms of organizations and management in general (Daddi *et al.*, 2018). One of the most demanding challenge that people have to deal with is elaborative understanding on the way ecological systems are to react on climate change (Smith et al., 2017).

Floods are one of the numerous extensive phenomena closely affiliated with the intense climate change-related natural disasters. During the 20th century, floods have led to the loss of more than 100,000 human lives while they have also affected over 1.4 billion people worldwide (Jonkman, 2005). The degradation of the natural environment has consequently resulted to an increase of vulnerability towards floods for lots of areas (Hirabayashi et al., 2013). The lowland area of Arta Greece suffered from such phenomena in 2015 where large areas near the river Arachthos were flooded (Fig.1).



Fig. 1: The impact of flooding in Arta Greece, 2015.

Overlapping threats arising from climate change effects on ecosystems, economy and society reveal that there is a need to create and in turn to improve an ability of individual and collective decision-making in order to enact effective responses in case of emergency, namely risk assessment strategy. Risk assessment, constitutes a process showing the understanding of nature and also the level of risk based on Risk Science which is case evident in the grounds of disaster: while understanding of the interaction between hazard, vulnerability exposure has significantly comprehensive and and sophisticated risk models and assessment methods (Adger. Brown and Surminski, 2018). Therefore, it is imperative for Local and Central Authorities to develop and implement innovative risk management policies. In fact, over the last years it has been observed that there is a great progress in disaster risk management policy, via the use of more accurate forecasting (Georgoulas et al., 2016; Karvelis et al., 2017), improved early warning systems, and better evacuation procedures (Krzhizhanovskaya, 2011). In Government, many policy-making decisions are concerned with risk management and setting priorities through the establishment of standard rules and guidance aiming at the reduction of devastating consequences of natural and other disasters (Kolios et al., 2015; Kolios et al., 2016; Kolios et al., 2017; Kolios et al., 2018).

Flood hazard maps have proven to be a useful tool in order to prevent flood damage. Fig. 2 presents the flood hazard map of Arachthos river for 2015 event. It is of outmost importance that advances on ICT technologies and the integration of intelligent algorithms have led to early flood warning systems that are always set to promptly inform people about ongoing and upcoming flood events, which in turn enables them to prevent the loss of life and property (Azam *et al.*, 2017).

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Fig. 2: Flood hazard map as displayed in our Web-GIS.

State-of-the-art flood early warning use systems meteorological information, water level data and also remote satellite monitoring data (optionally) as input sources (Pengelet al., 2013). Usually they are based on real-time monitoring (Quansah et al., 2010) and all the relevant information are fed into an interactive decision support system. The two main objectives of such systems are: a) to assist public authorities and citizens in choosing the appropriate flood protection measures and actions and in managing emergency situations (Krzhizhanovskaya et al., 2011) and b) to serve as a web-based information source for the public, responding to their needs for information on flooding conditions and the possibility of the river overflow. The developed system is composed of three major components: sensor network, processing/transmission unit, and database/application server. The real-time water level data and weather conditions are transmitted to the application server by utilizing the mobile General Packet Radio Service (GPRS) communication (Sunkpho and Ootamakorn, 2011); moreover, meteorological data were used from an open source meteorological portal (Masinde and Bagula, 2011).

Here, the aim of this study is to present the early warning system of the wider area of RiverArachthos, Greece. Through the creation and operation of an electronic database, and also by the installation of special equipment and the design and development of a Geographical Information System for the broader area, finally, a risk assessment model is going to be developed, which will be the core of a Decision Support System in case of flood events. The information system is to provide targeted information for local authorities, citizens and multiple stakeholders.

## 2. STUDY AREA

The study area includes part of Arachthos River as well as its broadest catchment area. With 110 km length and 2,209 km<sup>2</sup> catchment area, Arachthos River is the largest river in Epirus and the 8th largest nationally. It has its springs in northern Pindos, specifically Mount Lakmona, at Oxyas-Despotis at altitude of 1,700 m, leading to the northeast of the Amvrakikos sea gulf. In his tributaries included Kalarrytikos, Zagoritikos and Metsovitikos (MINISTRY OF ENVIRONMENT & ENERGY, 2018).



Fig.3: The Arachthos river with its two dams, Pournari I and Pournari II.

The climate of the study area is temperate, mild, changing to continental while moving east and mountainous. The absolute maximum and minimum temperatures are at 41 °C during the summer and -7.2 °C during the winter respectively (Vriniotis and Papadopoulou, 2004). Upstream of the city of Arta, the Arachthos river meets in turn a hydroelectric dam (Pournari I), which is the second largest dam in Greece after the Mornos dam and a regulating dam (Pournari II), to control the outflows of Pournari I and irrigation of arable land, as Figure 3 shows. Following its path, Arachthos river crosses the plain of Arta with a length of about 28 km, from the city of Arta to the of estuaries Amvrakikos Gulf (MINISTRY OF ENVIRONMENT & ENERGY, 2018).

## 3. SYSTEM ARCHITECTURE & DESIGN

The developed Web-GIS architecture is composed of following main components: The Client, the Web Server, the Database and the External Sources provider (Fig. 4).



Fig.4: The architecture of the proposed Web-GIS.

#### 3.1 Client

The client component is divided into three main parts. The first part is the front-end development where there are used the following scripting languages: Javascript, HTML,CSS and Jquery. Those scripting languages are used to develop the functionality and the template of the Web-GIS. The second part is the geographical data visualization module where Javascript and the Google Maps API (Google Maps Platform, 2018) are applied in order to visualize the geographical data on a responsive map. The third part of the client is the display of the meteorological data that include a number of weather parameters such as rainfall, wind speed, wind direction and barometric pressure. All these data are represented as a time series plot using the lightweight but yet powerful Javascript library Dygraph. More details for each of the parts of the client are described below:

## Web page Design - Template

The front-end part of the Web-GIS is created with the combination of HTML5/CSS/JavaScript/Jquery. With the use of those scripting languages a full responsive website is created. The responsive design is used to ensure that the users could have a good viewing experience in any device (mobile or tablet). HTML5 is used for the creation of the elements of the web pages and the CSS is used to create the style of the web page. The JavaScript is responsible to load the scripts of the Web-GIS and finally the system makes use of AJAX from the JQuery (J Query, n.d) in order to load the data from the database.

## Display Map

The Google Maps API provides a set of tools to visualize the geographical data. Those tools vary and help us to plot the different layers. Maps JavaScript API version 3 is used to plot markers and the Keyhole Markup Language (KML) files, are representing a different set of data for each case (Google Maps Platform, 2018). KML file formats are a special type of files used in order to display geographic data.

#### Time Series plot

Dygraphs is an open source JavaScript library (Dygraphs, n.d). This library provides a set of tools in order to create the realtime charts of the meteorological data which are stored in our database. Due to the large number of data that are received from six meteorological stations a library that can handle dense data sets is required.

## 3.2 External Sources

Enhydris is an open-source database system which provides meteorological and hydrological data from stations located all over Greece. The access to the Enhydris data is free and the Enhydris API provides data every ten minutes data such as rainfall, temperature, wind speed and wind direction (Christofides et al. 2011). The API is an application programming interface which allows the interaction of one software with another. It defines a set of rules or methods so that to interact with other software in order to obtain specific information. Using web requests to the Enhydris APIall the meteorological data are being retrieved and visualized. Finally, the data are being processed and stored in the created database in a suitable form for future processing.

#### 3.3 Web Server

Web-GIS is running through a web server that handles all the requests from clients and it is also responsible for data acquisition and storage into the database. An HTTP server uses the http protocol and can deliver content like web pages or web applications to the end-users device. The HTTP services of the Web-GIS are handled with the Apache Web Server in order to respond to multiple requests, simultaneous connections as well as to handle static files.

#### Data acquisition

In order to acquire all the data from the external sources Node.js is used as shown in Figure 5. This is a JavaScript runtime environment which allows server-side scripting. The Javascript functions executing in the server before the content is sent to the client web browser (Node.js Foundation, n.d.).



Fig.5: An illustrative example of the node.js functionality.

#### 3.4 Database

The communication between the front-end and the back-end of the platform is achieved through JQuery and PHP. PHP works as an intermediary to the front-end and the back-end providing SQL queries to the database. Then, the results are used by the Google API functions to visualise the data.

## 4. DATA USED AND DISPLAY

The Enhydris portal is used in order to retrieve data from four different meteorological stations. Those stations are installed at nearby villages of Kampi, Kommeno, Kompoti and at facilities of the Technological Institute of Epirus in Kostakioi, Arta. The grid of the meteorological stations can be accessed by the Web-GIS system which is displayed in Figure 6.



Fig.6: The location of the meteorological stations displayed in our Web-GIS.

From those stations the meteorological parameters of wind direction, wind speed, rainfall and temperature data are retrieved and stored in the database. The measurement units of each of meteorological parameter are illustrated at Table 1.

Table 1. Meteorological Parameters and their units.

Meteorological Parameter	Тор
Wind Speed	m/s
Rainfall	Mm
Temperature	°C
Pressure	Mb

Figure 7 illustrates the wind speed data received from a specific meteorological station, which was selected at Web-GIS.



Fig.7: The time series display of the wind speed.

Web-GIS illustrates also the data on water levels at the area of two Bridges of Arachthos river, Arta (Figure 8) and Neochori (Figure 9).



Fig. 8 : The water level in meters in Arta Bridge.



Fig. 9 :The water level in meters in Neochori Bridge.

In order to develop a flood hazard zone heatmap a number of points are extracted for which the length of the cross - section is less than 50 m as it is shown in Figure 10. The total number of points extracted are twenty-one and they are all located downstream of the new Bridge of Arta.



Fig. 10: The Extraction of a point for which the river cross section is less than 50 m.

After the extraction of the points of interest, Google Maps API is used to construct a flood hazard heatmap as shown in Figure 11.



Fig. 11: The extracted flood hazard heatmap.

The riverbed as well as the river zone of the River Arachthos are extracted. Figure 12 displays an example of the Arachthos River Zone.







Fig. 12: (a)The riverbed and (b) the river zone of the River Arachthos, Greece.

The extracted road network near the river Arachthos is displayed at Figure 13.



Fig. 13: The road network displayed next to Arachthos river.

# 6. CONCLUSIONS

This work presents a Web-based GIS platform for the monitoring of river flood and risk prediction along the riversides of Arachthos. The architecture and the main technical details are described and there is also presented how to integrate and display different type of information.

The integrated information system for flood events monitoring, management and early warning is expected to encourage stakeholders' participation in decision making procedures in order to improve the efficiency and promptness in flood crisis management for the broader area o Arachthos basin.

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