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Design of a Smart Early Warning Hydrometeorological System: The Easy Project in Ermionida †

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Abstract: Climate change is linked to a higher risk of hydrometeorological disasters, which are driven by both the increased global surface temperature, which leads to more frequent droughts, and heavy rainfall events inducing floods. The Municipality of Ermionida is a dry area in Greece facing flash flood events, mainly during the autumn and early winter period. To address this, the Municipal Enterprise for Water and Wastewater of Ermionida (DEYA.ER) and the Laboratory of Climatology and Atmospheric (LACAE) of NKUA are collaborating on a project entitled "Design of a smart early warning hydrometeorological system (EASY)". The project aims to develop an integrated local-scale forecasting system for flood awareness and, ultimately, for protection purposes. In the context of EASY, an online tool for data processing is provided, including hydrometric and meteorological monitoring, and it is a user-friendly platform that allows real-time access to data and enables the capability of designing specific diagrams according to the parameter and station.

Keywords: civil protection; hydrometeorological hazards; floods; early warning systems

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1. Introduction

A hydrometeorological phenomenon can be considered as extreme in a particular area based on its intensity, duration and frequency. An extreme event is defined as the value of a weather or climate variable being significantly higher or lower than a defined threshold and having negative effects on society, the economy and the environment in general [1–4]. Climate change is strongly linked to the increase in such phenomena, especially in the Mediterranean dry areas that face both extensive droughts and severe flood events.

The Municipality of Ermionida, located in Argolida Regional Unit, Peloponnese, Greece, is a dry area, where the indicators of climate change are becoming more pronounced; the intensification of heat waves, prolonged drought periods, and extreme precipitation are the main drivers of flash flooding [5,6]. Hence, there is a need to take actions to strengthen local preparedness, including historical data analysis, ongoing monitoring and systematic documentation of the climatic regime within the region. Additionally, it is essential to assess the geomorphological, geological and hydrological features along with the anthropogenic activities in the study area to better understand the risk. By analyzing these factors, particularly for regions that lack historic records, the identification and precise delineation of areas that are under high susceptibility can be more reliable [4,5,7,8].

Among the strategies that are being implemented under climate change adaptation for Ermionida, and more particularly for flood protection and preparedness of the most vulnerable areas, is the project entitled "Design of a smart early warning hydrometeorological

system (EASY)". Within the framework of this project, both the Municipal Enterprise for Water and Wastewater of Ermionida (DEYA.ERM) and the Laboratory of Climatology and Atmospheric (LACAE) of NKUA are collaborating in order to develop the EASY system: a user-friendly online tool, designed with the scope of monitoring and processing data from connected sensors, i.e., (i) stage–discharge records from hydrometric stations installed on the surrounding torrents and (ii) several meteorological parameters from meteorological stations installed in several areas in the watershed. This online tool allows the user to access data from a central screen and to design specific diagrams according to the parameter and station of interest. Finally, these sensors are connected to a datalogger with an internal 4G modem for real-time monitoring that allows inter-operability with a 1D/2D hydraulic model with the scope of issuing warnings.

2. Materials and Methods

The EASY system includes the design and operation of an early warning system for flood events and an application for the processing of measurements. These applications obtain information from Internet of Things (IoT) sensors, which will be installed in the area, and then measurements are depicted in a user-friendly interface, as shown in Figure 1.

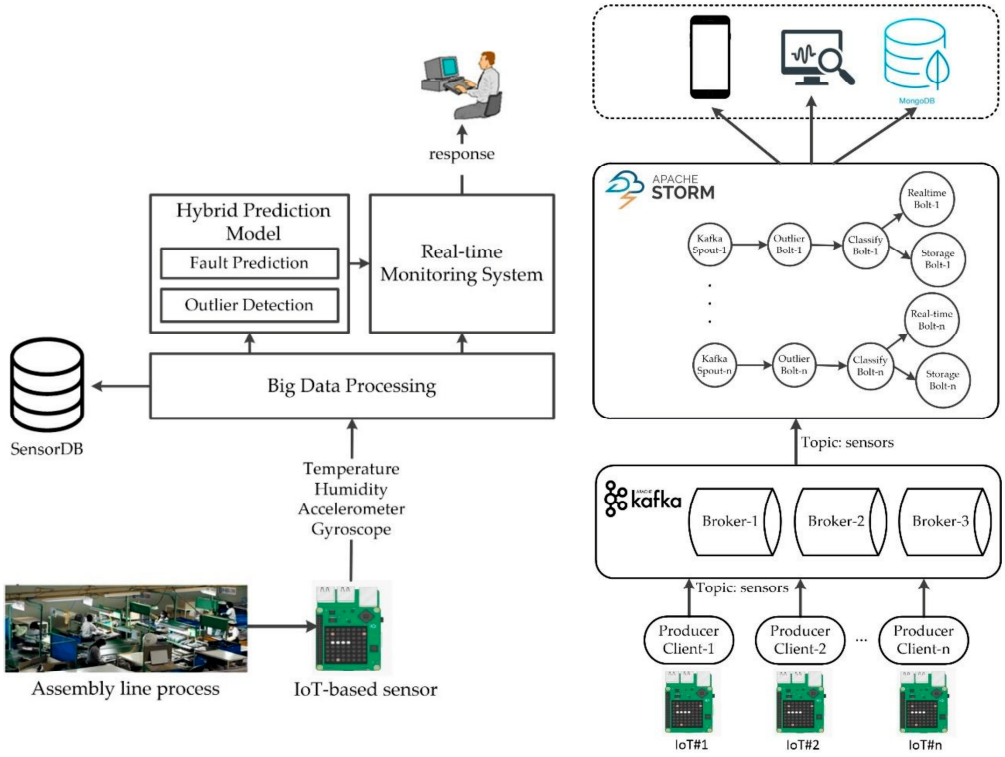

Figure 1. The EASY system framework.

2.1. IoT Sensors

The utilization of IoT sensors plays a crucial role in enhancing environmental monitoring and management systems [9]. These sensors, embedded in various devices and infrastructure, enable the collection and transmission of real-time data on environmental conditions. For the project's purposes, the types of IoT sensors that will be used are as follows:

1. Tipping Bucket Rainfall Sensor: an instrument for testing rainfall in nature. In order to meet the requirement of information transmission, processing, recording and display, the amount of rainfall is converted to a pulse output.
2. Ultrasonic Automatic Weather Sensor: an automatic weather instrument that simultaneously measures the atmospheric temperature, atmospheric humidity, air pressure,

wind speed, wind direction, solar radiation, illuminance/UV, dust concentration and precipitation. Temperature, humidity and air pressure sensors are placed within the radiation shield.

3. Ultrasonic liquid level sensors: sensors that emit ultrasonic pulses of sound, use piezoelectric transducers to generate sound waves in the ultrasonic range (typically, frequencies exceed 40 KHz) and can operate with both liquid and dry media. In the frame of the current study, they are used to estimate the velocity of soundwaves in liquid media.

2.2. Development of Smart Hydrometeorological Early Warning System

The second main component of EASY is a contributing system for the design of a smart hydrometeorological early warning system, which will be integrated with the equipment. This system will collect various types of data to effectively monitor and evaluate the potential of flood occurrence. Such a system typically includes:

1. Hydrological data, i.e., measurements of stage, discharge, etc.
2. Meteorological data, i.e., available information on weather patterns and predictions for precipitation depth, wind speed, air temperature and atmospheric pressure, and corresponding real-time monitoring.
3. Historical data, i.e., long-term records of past flood events that may provide an indicative scheme for the identification of future flood events.

Finally, the equipment will be installed within the area according to the WMO guidelines [10,11]. The application will be developed to fulfill the requirements of monitoring hydrological parameters, issuing warnings for flood events, collecting data from the installed stations, generating alarms and storing the historical hydrological data of the area. The application will also interconnect all available stations and will be installed in a central server to enable remote monitoring from stakeholders and decision-makers for civil protection purposes, and from the personnel of both the Municipality of Ermionida and the DEYA.ERM for local management purposes. In the frame of EASY, a user-friendly web platform will be developed to facilitate the operation of an early warning system (EWS).

2.3. Development of the Application for the Meteorological Measurements

The development of an application for the meteorological measurement system is the final purpose of the project. LACAE will be the scientific organization responsible for overseeing the installed stations and gathering information. The application will be developed to establish a direct connection with the early warning system for flood events, as described in the previous section. Through the operation of this application, meteorological variable monitoring, measurement evaluation in case there are hydrometeorological hazards and the creation of a database regarding historical meteorological data may be achieved. This application will have a complete integration with and serve as an extension of the local flood EWS. In general, an application for the meteorological measurement system collects various types of data to monitor and analyze meteorological conditions.

3. Expected Results and Conclusions

The design of a smart early warning hydrometeorological system for Ermionida, named EASY, will contribute to support the operation of a local, integrated flood EWS that is designed to issue warnings in case extreme weather events occur and to guide local authorities, such as the civil protection and the municipality. The system that is under development is characterized by the following capabilities:

- Map viewer. A larger map on the system's central screen will be displayed, including the available stations and the ability to view the latest measurements and station information in pop-up windows that emerge on the map.
- Display. It will allow the simultaneous creation of multiple graphical representations with data from all available sensors at each station. Multiple options should be

available in the graphical representation, such as zooming, viewing selected graphical representations from those already generated, etc.

- Data acquisition. Viewing/exporting all measurements from each station will be possible. It will have the ability to export data per station and per sensor in CSV and/or Excel format.
- Chart generator. Automatic generation of charts for one or more selected measurements, per measurement station and per time interval, based on user-defined parameters, will be possible.
- Analyst. There will be the possibility of automatic processing of historical time series to calculate various statistical measures (e.g., mean, minimum, maximum) on an hourly, daily, monthly and annual basis.
- EWS thresholds. It will have the capability to display notification thresholds on the graphical representations of respective parameters.
- Accessibility for users. The platform will allow the simultaneous monitoring of measurements by different users. It will support graded access for the roles (a) general administrator, (b) group administrator and (c) regular user.

The implementation of EASY marks a significant advancement in enhancing the ability to monitor and respond to flood events, ultimately contributing to improved resilience and disaster management strategies.

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