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Research Article

An Evaluation of the Effectiveness of Early Warning Detection Systems: Benefits, Limitations, Recommendations, and Future Directions

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Abstract
One of the deadliest natural disasters that can occur is flooding, which occurs when the water level rises. It will take a long time to recover from the flood, in addition to causing more harm. The only way to reduce the damage and protect human life is to regularly check the water level. Water levels in systems such as dams and reservoirs must be regularly checked and monitored. The water level can be predicted by the proposed system. The research for the Flood Monitoring System is based on the GSM sim900A module, which will be interfaced with the most widely used microcontroller, the "ATmega328," which is also utilized in the Arduino Uno. This microcontroller will be linked to a water level monitoring sensor in order to keep an eye on the water level. In this work, we have examined the advantages and disadvantages of the early warning detecting system.

Keywords: *Future Directions and Recommendations, Impacts, GSM Module, Water level sensor, Wireless Sensor Network, Flood detection.*

I. INTRODUCTION

Flooding is one of the most dangerous natural disasters that can occur due to rising water levels. The damage caused by the flood will be more harmful and the time taken for recovery will take a long period of time. The only way to reduce the damage and save the lives of people is to frequently detect the water level. The level of the water in systems such as dams, reservoirs, etc., is to be frequently tested and monitored. The water level can be predicted by the proposed system. The Internet of Things (IoT) is an embedded system of hardware and software. Where hardware includes chips and sensors and software includes data storage and analysis, the communication between any systems is done through wireless sensor networks. IoT always connects the physical world to the internet with the help of sensors within or connected to it. Where in this system, IoT is connected to some sensors to have a real-time calculation. These level predictions are transmitted to the application developed with the help of Android to have an alert. In developed countries like the US, Japan, and so forth, the flooding issue is limited altogether and doesn't influence much because of the accessibility of the crisis framework. Yet, the agricultural nations like India, Brazil, and so on are enduring a ton during the flood. The number of people who have died as a result of flooding in various parts of our country has been steadily increasing. Two years prior, the flood that happened in Chennai, the capital of Tamil Nadu, came about with an immaterial death toll and property. At whatever point, flooding happens, living regions close to the riverbank and downstream territory are more seriously influenced than others. They should be alarmed significantly sooner to have an additional opportunity to clear it right away. During the Chennai flood in 2015, counterfeit word got out. For example, a bogus message which said two lakes had penetrated and Chennai had been cut off from the rest of the areas spread frenzy among workers, particularly those that were abandoned for quite a long time on the blood vessel Mount Road on Monday night. To keep away from the present circumstance, we need an approved admonition framework. Our framework gives

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such data so that individuals can keep away from bogus news. Furthermore, the framework utilizes voice call as it is useful for individuals who don't have a clue how to peruse the instant message. The Flood Monitoring System research is totally based on the GSM sim900A module, which will be interfaced with the most well-known microcontroller, the "ATmega328", the equivalent microcontroller which is utilized in the Arduino Uno. A water level observing sensor will likewise be associated with this microcontroller to monitor the water level. As of now, I have chosen to utilize the ultrasonic Sensor for this reason. In any case, as I am examining and pondering an elective sensor that can be a lot less expensive and more solid than this one, assuming I am prevailing with regards to making my own sensor for this work, I will supplant the ultrasonic sensor with my planned water level observing sensor. In this venture, we will have the primary checking station, which will be a PC. On this PC, we will have an observing application, which we will plan. This PC will be then associated with the Arduino Uno through a USB link. The Arduino Uno will then be interfaced with the GSM module to get messages from the flood observing module introduced in various spaces of the area or Pakistan if this task is executed at the national level [34].

II. KEY RECOMMENDATIONS

i. Adopt People-Centred Frameworks: Shift away from top-down, one-way messaging toward community-based and decentralized local leadership that incorporates indigenous knowledge.
ii. Strengthen the Four Pillars: Align local and national initiatives with the global UNDRR Early Warnings for All framework, focusing on risk knowledge, monitoring, communication, and preparedness.
iii. Improve Multi-Channel Communication: Use diverse mobile, social, and local radio networks to ensure urgent messages reach everyone, including vulnerable or remote demographics.
iv. Mandate Regular Drills and Education: Combine technological deployment with continuous public education, standard operating manuals, and community disaster drills.

III. FUTURE DIRECTIONS

i. AI and IoT Integration: Integrating artificial intelligence for consistent hazard forecasting alongside Internet of Things (IoT) sensors and GIS mapping to drastically improve prediction accuracy.
ii. Cloud-Based Interoperability: Transitioning from legacy, single-hazard platforms to cloud-based EWS capable of real-time big data analytics and multi-hazard coordination.
iii. Impact-Based Forecasting: Moving past simple threshold alerts (e.g., "how high the water will rise") toward impact-based predictions (e.g., "what will happen to specific roads, hospitals, and homes") to force immediate, decisive action [39].

IV. LITERATURE REVIEW

The Classification of Flood Levels with Gait Analysis of Smartphone Sensor Data was investigated by Panchal [1]. Miau [2] studied the flood forecast and anomaly detection based on in-depth studies. Tang's findings from SAR, GPS, and tide-gauge observations [3]. A Hierarchical Color Petri-Net Based Multi-Agent System for Flood Monitoring, Prediction, and Rescue (FMPR) was investigated by Akhtar [4]. IoT Enabled Flood Severity Prediction through Ensemble Machine Learning Model was studied by [5]. Satellite Flood Inundation Assessment and Forecast Using SMAP and Landsat studied by Du [6]. Citizens' Campaign for Environmental Water Monitoring: Lessons from Field Experiments researched by Assumpcao [7]. Liu [8] conducted research on the risk of water discharge in the hydroelectric power generation process. Wakabayashi [9] investigated CRML: Convolutional Regression Model with Machine Learning for Hydrological Forecasting, while Chen [10] investigated CRML: Convolutional Regression Model with Machine Learning for Hydrological Forecasting. Flood Prediction Using Rainfall Flow Patterns in Watershed Data-Sparse studied by Zhu [11]. Flood Area Mapping: An Integrated Method Using Deep Learning and Regional Development Using UAV Optical Data, researched by Hashemi-Beni [12]. Qin [13] investigated a remotely operated siphon system to discharge water from wetlands and shallow ponds. Milani [14] investigated the characterization of flood impacts on the Swiss Flood Plain using interannual time series satellite imagery. Pourghasemi's research [15]. Research on Synchronous LoRa Mesh Networks for Monitoring Processes in Underground Infrastructure by Ebi [16]. How Satellite Soil Moisture Data Can Help Monitor Climate Change Impacts: The SMAP Case Study researched by Forgotson [17]. Mozambique Flood (2019) Caused by Tropical Cyclone Idai as Observed from Sentinel-1 and Sentinel-2 Images Studied by Guo [18]. Fleming [19] investigated a machine learning metasystem. For forecasting seasonal water availability based on strong probabilistic regression in the US West. Based on Wu's Deep Learning Research [20]. Bangira [21] investigated the Mapping of Flood Area in the Caprivi Flood Plain Using Sentinel-1 Time Series. ORFFM: Mughal's Semantic Model of River Flow and Ontology-Based Flood Mitigation [22]. Learning-Based Unmanned Surveillance System for Observing Water Levels was investigated by Pan [23]. Berezowski [24] investigated river gauge observations in order to map flood levels for synthetic aperture radar time series based on river gauge observations. Hydrological analysis using Big Data Satellite Remote Sensing and the CREST Model studied by Ma [25]. Riparian Wetland Mapping and Inundation Monitoring Using Bistatic Amplitude and Coherence Data from the TanDEM-X Mission studied by Mleczko [26]. The Detection of Historical Alarm Sequences Using Alarm Events and Coactivation Constraints were investigated by [27]. The Deep Sensing of Urban Puddles was investigated by Lo [28]. Flood Net: A High-Resolution Aerial Image Data

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Collection for Understanding Post-Flood Landscapes, researched by Rahnemoonfar [29]. Then, Peng [30] investigated Urban Flood Mapping Using Bit Temporal Multispectral Images Using a Self-Supervised Learning Framework. The development of an Extreme Gradient Enhancement Model Integrated with an Evolutionary Algorithm for Hourly Water Level Prediction was investigated by Nguyen [31]. The Development of an Extreme Gradient Enhancement Model Integrated with an Evolutionary Algorithm for Hourly Water Level Prediction was investigated by Landuyt [32]. Towards Operational Flood Monitoring in Flanders Using Sentinel-1, researched by Caraka [33]. In [35], the Department of Public Works and Spatial Planning for Pekanbaru City is tasked with finding out information on flood-prone points, where the information obtained is only from local residents in the form of photos, videos, and reports of residents in flood-affected areas. The Public Works and Spatial Planning Office of Pekanbaru City still do not have an automatic system for detecting vulnerable points in flood locations. As we have seen, floods on Jalan Kulim, Tampan Village can occur 2 times a year with a flood intensity of 2 meters, where the tributary of the Siak River on Jalan Kulim, Tampan Village reaches a height of 2.5 meters, so you can be sure that Kulim Street, Tampan Village floods as well as causes economic losses which result in damage to houses and the contents of objects in the house and even loss of other valuables. Floods also cause health problems. With this problem, the authors found a solution for the Public Works and Spatial Planning Office of Pekanbaru City in building a flood detection system in flood-prone areas. The authors used a GSM SIM 900A tool which would send messages to the parties concerned about the state of the water. 2. With this tool, the community can minimize the losses they suffer because it will provide periodic information about the height of the tributaries on Jalan Kulim, Tampan Village, so that it allows people to evacuate and save assets that can be saved.

V. ADVANTAGES AND DISADVANTAGES OF EARLY FLOOD DETECTION SYSTEM

Table 1: Impacts and drawbacks of flood detection system

Advantages	Disadvantages
i. The impact of flooding is reduced.	i. Warnings don't stop a flood from happening.
ii. Warnings give people time to move possessions upstairs, put sandbags in position and to evacuate.	ii. Living in a place that gets lots of warnings could make it difficult to get insurance.
	iii. People may not hear or have access to warnings [37].

VI. COMPONENTS REQUIRED FOR IMPLEMENTING THE FLOOD DETECTION SYSTEM

1. Arduino UNO

Arduino is an open-source platform that is used to develop research in electronics. It can be easily programmed, erased, and reprogrammed at any instant of time. There are many Arduino boards available on the market, like the Arduino UNO, Arduino Nano, Arduino Mega, Arduino Lily Pad, etc., with different specifications according to their use. This board is usually programmed using the software Arduino IDE using a micro-USB cable. The ATmega328 comes with a preprogrammed onboard boot loader, which makes it easier to upload the code without the help of the external hardware. It has vast application in making electronics projects or products. The C and C++ languages are used to program the board, which is very easy to learn and use.

2. HC-SR04 Ultrasonic Sensor

The HC-SR04 is an ultrasonic sensor that helps to measure distances in many places with no human contact. It works on the same principle as radar and SONAR and provides an efficient way of measuring distances in a very precise way. Theoretically, it can measure distances up to 450 cm, but practically, it can measure distances from 2 cm to 80 cm with an accuracy of 3 mm. It is operated at 5 volts, with a current of less than 15 mA and a 40 Hz frequency. The HC-SR04 has one transmitter and one receiver installed on it. Distance = Speed x Time, which is the basic speed, distance, and time formula that we all learned in school, is used to calculate the distance. The transmitter of the HC-SR04 sensor transmits an ultrasonic wave into the air. If this wave is reflected by some object in the range of the sensor, then the reflected wave in the air is received by the receiver of the sensor. So, to calculate the distance using the above formula, we should know the speed and time. We know that the universal speed of the ultrasonic wave is around 330 m/s. The time is measured by the circuit built into the microcontroller. The echo pin gets high for the time period that the ultrasonic wave takes to return to the receiver. This way, we can calculate the distance between the object and the HC-SR04 ultrasonic sensor.

3. 16×2 LCD Display

Interfacing a 16 x 2 LCD with an Arduino UNO is pretty easy. There are various types of LCDs available on the market, but the one we are using in this project is 162, which means it has two rows and, in each row, we can display 16 characters. This module has an HD44780 driver from Hitachi on it, which helps to interface and communicate with the microcontrollers. This LCD can work in 4-bit mode and 8-bit mode. In 4-bit mode, only four data pins are required to establish a connection between the LCD and the microcontroller, whereas in 8-bit mode, eight data pins are required. Here we are going to use it in 4-bit mode as it requires a smaller number of wires and simplifies the circuit. Let's look at the pin description of the 162 LCD [36].

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4. Buzzer

The buzzer is an audio signaling device like a beeper or buzzer. It may be electromechanical, piezoelectric, or mechanical in type. The main function of this is to convert the signal from audio to sound. Generally, it is powered by DC voltage and used in timers, alarm devices, printers, alarms, computers, etc. Based on the various designs, it can generate different sounds like alarms, music, bells, and sirens.

CONCLUSION

For this study, we have examined numerous literatures about flood detection systems. I have also discussed the various components of the flood detecting system. Numerous research covered in this article have also noted the impact [38] of implementing the flood detecting system [40].

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