

AquaVigil: A Multi-Level Flood Detection and Emergency Response System

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Abstract—The AquaVigil Hardware System is a flood monitoring and an emergency response device which is designed to detect rising water levels and give alerts to the locals and the emergency services to prevent heavy damage. The system consists of a three-level alert mechanism when the water level is at Level 1, an alarm is generated to alert nearby residents. When the water level reaches to the Level 2, the alarm sounds longer, and an SMS is sent to nearby helpline services. At Level 3, the alarm beeps continuously, and an emergency call is automatically set and is made to call the helpline services, initiating the first phase of rescue operations. The LCD screen provides real-time water level updates, spreading awareness of rising water conditions. Additionally, the system is incorporated with an emergency button, which, when pressed, sends the user's GPS location to emergency services, indicating that they have missed the first evacuation phase and require urgent help. The device is connected by a stable energy source, making sure that there is continuous operation during floods. The AquaVigil system plays an important role in real-time flood monitoring, automatic emergency communication, and rescue coordination, therefore, improving disaster response and reducing the risk of huge loss of life.

Index Terms—Flood Monitoring, Emergency Response, IoT- Based Disaster Management, GPS-Enabled Alert System

I. INTRODUCTION

Floods are among the most destructive natural disasters, which cause significant risks to human lives, infrastructure, and economy. The increasing intensity of floods due to climate change demand effective early warning and monitoring systems. AquaVigil, a flood detection and response system, aims to address these challenges by developing advanced Internet of Things (IoT) sensors, geographical APIs, and real-time communication

technologies. The system generates alarms when water levels rise to certain threshold level, it notifies nearby residents by generating an alarm. Its unique features include real-time monitoring, SMS/Call alerts via GSM, and an emergency button for the people who've missed the initial flood evacuation phase. By getting AquaVigil into action, it gradually reduces the loss of life and property helping lots of people who ever are in danger.

AquaVigil consists of water level sensors, GSM communication modules, and GPS-enabled geolocation services to deliver real-time alerts and critical information to affected populations. The system activates alarms when water levels reach dangerous thresholds, sends SMS and call alerts to nearby helpline services. To enhance its functionality further, AquaVigil involves cloud-based analysis to process sensor data efficiently, ensuring accuracy and reliability even in difficult environments [2], [3]. The primary goal of AquaVigil is to bridge the gap between conventional flood monitoring solutions and modern technological advancements. For instance, systems like those proposed by Azid et al. (2015) focused on SMS-based flood warnings but lacked dynamic geological features and real-time resource mapping [2]. Similarly, Xu et al. (2016) highlighted the potential of IoT devices for local rain monitoring but did not address community-specific emergency needs [3]. AquaVigil mainly helps the people who come under the red zone areas at the time of flood. In addition to detecting floods, AquaVigil makes sure that it gives a proactive approach in disaster management by incorporating features like emergency GPS tracking, Emergency button, the timely alerts generated at different levels of flood. The incorporation of multi-way alert mechanisms—audible alarms, emergency button, and text notifications which makes AquaVigil accessible and

effective for different populations, including those in remote and underprivileged areas [9], [19].

II. MOTIVATION

The need to notice floods which is a natural disaster. Affecting millions of people annually and causing devastating loss of life and property, this is the main reason of innovating AquaVigil. In many regions, especially rural and remote areas, the lack of dependable and affordable flood detection systems remains a crucial challenge. Traditional approaches often have expensive infrastructure and manual intervention, making them unsuitable for deployment. AquaVigil is designed to be an affordable, portable, and user-friendly flood detecting device that delivers real-time alerts to rescue teams. By utilizing advanced sensors, GPS tracking, AquaVigil ensures continuous operation even when there is no power, offering dependable functionality in emergencies. Its ease of deployment and accessibility make it an important tool for both underserved rural communities and urban populations, enabling timely responses that can save lives. As floods grow more and get severe due to climate change, AquaVigil provides a cost-effective solution to mitigate their devastating impacts. By signaling the communities with early warnings and actions, AquaVigil plays a crucial role in reducing the destruction caused by these increasingly flood disasters.

III. LITERATURE REVIEW

The increasing effects of floods worldwide have made everyone to conduct extensive research into early warning systems and flood monitoring technologies. Various studies have mentioned the important role of IoT, GSM modules, and geo technology in addressing these challenges, we developed an early warning and flood monitoring system that relied on SMS notifications to inform emergency communities of danger. Their work bridged the gap for the need for simple and cost-effective communication methods to ensure timely alerts, especially in regions with limited technological access [2]. An intelligent wireless sensor node utilizing a Raspberry Pi for localized monitoring of rain. Their system demonstrated the effectiveness of IoT devices in obtaining real-time

environmental data for targeted response strategies [3].

A flood monitoring prototype combining Arduino and GSM modules with Google Maps integration. This system provided users with a visual representation of flood-prone areas, highlighting the potential of geospatial tools for real-time decision-making [5]. Similarly, a GSM-based prototype capable of controlling electrical appliances during emergencies. While primarily focused on power management, this work demonstrated the scalability of GSM modules in disaster response systems [6].

The application of fog computing to disaster management, presenting a model for dynamic resource allocation through micro data centers. This approach addressed the challenges of delay and scalability in cloud-based flood monitoring systems, paving the way for more efficient data processing during emergencies [9].

An IoT-based flood early warning system that used water level sensors and GSM modules to send SMS notifications. Their work focused on providing affordable and user-friendly solutions to minimize the impact of flooding in low-resource settings [17]. Additionally, an IoT-enabled water level monitoring and alert system, integrating wireless sensor networks to ensure robust communication and real-time updates during flood events [19].

Recent advancements in sensor technology and cloud integration have further improved flood detection systems. An IoT-enabled flood alert system using wireless sensor networks to track rainfall and water levels. Their research highlighted the importance of early warnings to reduce damage and loss of life in flood-prone regions [21].

Incorporating advanced technologies, researchers like decision-making models based on trust for IoT systems. Their work underscored the potential of intelligent algorithms in enhancing system reliability and user trust in emergency scenarios [14]. Similarly, a low-cost flood detection method using sensors and GSM modules, emphasizing accessibility for rural and underserved areas [18].

Furthermore, recent studies have explored the integration of cloud computing, machine learning, and big data analytics in flood management. Fog computing, as outlined has proven instrumental in reducing latency during critical situations, while predictive analytics using historical data sets has

facilitated better planning and resource allocation [9], [19]. These innovations highlight the evolution of flood management systems from reactive measures to proactive and predictive solutions.

AquaVigil builds upon these foundational studies by combining the strengths of IoT, GSM, GPS, and advanced analytics to create a perfect flood detection and response system. Unlike prior approaches that focus on either water level monitoring or communication, AquaVigil integrates real-time geospatial mapping, emergency resource tracking, and user interfaces. This approach ensures early detection, effective communication, and actionable understandings for communities and authorities.

IV. FLOW CHART

The AquaVigil system's operating flow is shown in Figure 1, which begins when the system is being turned on to continuously monitor the water levels. Checking for the presence of water is the first step in the process. The mechanism go back to continue monitoring if no water is found. The next action to take, though, in the event that water is found, is to determine whether the water level has reached a hazardous level. The device sounds an alert and notifies users by SMS or call if the water level exceeds the threshold value.

Here where the first phase of evacuation starts. The person who had missed the first phase evacuation when presses the emergency button, immediately the location is being sent to the nearby helpline services. Indicating them that some person had missed the first evacuation phase. The system initiates the GPS module to trace the impacted area and notifies nearby rescue stations. As part of the emergency process, it is determined whether the user has pressed the emergency button, which helps rescue teams locate the affected location quickly.

The system also detects the presence of power, allowing it to switch between solar power and backup battery power as needed. If the device is placed in standby mode when no dangerous water level is detected, it performs regular checks while in standby and remains ready to resume monitoring. AquaVigil ensures both early detection and real-time communication to relevant authorities, ensuring immediate response.

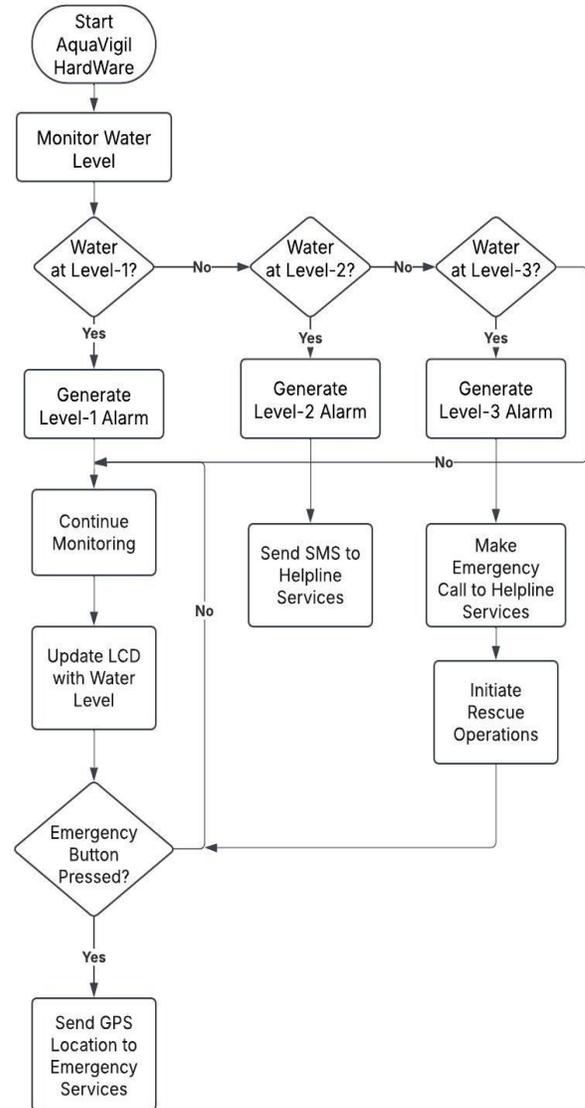


Fig. 1. Flow Chart

The above flowchart gives the user the overall working of the AquaVigil hardware system. As mentioned in the abstract, the flowchart clearly demonstrates how the hardware system of AquaVigil works. It triggers the alarm when the water level reaches the level 1 making sure to alert the locals so that they can evacuate the place immediately. When the water level reaches level 2, the alarm is generated different from the alarm which was generated at level 1. This time an SMS is automatically sent to the nearby helpline services. Indicating them that the water level has reached to level 2 at a particular place.

When the water level is reached to level 3, a call is being to sent to the nearest emergency services. The

device also generates a continuous alarm to make people get evacuate from their home immediately. As mentioned in the flowchart, the device consists of an emergency button. People who didn't get rescued during the initial phase of the flood evacuation process when pressed this button, their gps location is sent to the helpline services. Indicating them that some people are left behind who didn't get rescued during initial phase of rescue process.

V. SYSTEM ARCHITECTURE

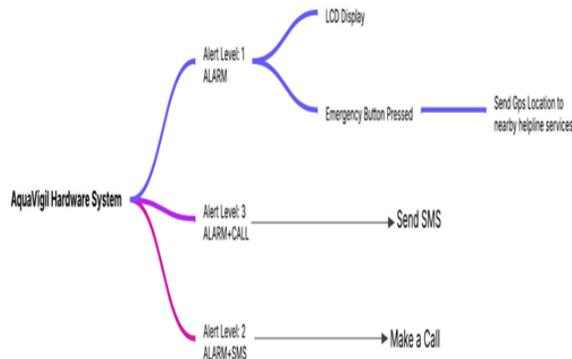


Fig. 2. System Architecture diagram for AquaVigil Hardware

The AquaVigil Hardware is a flood monitoring and emergency response device which is designed to find rising water levels and give alerts to residents according to the flood level detected and emergency services. The hardware consists of different hardware and software components which are working together to get ready for the incoming disaster and response. It is built using water level sensor which continuously monitors the flood conditions, also a microcontroller is used which processes sensor's data where an alarm is being generated, and a GSM module such that it is set to send SMS notifications and emergency calls itself automatically. An LCD screen is added to the hardware system which provides updates. Also, an emergency button with GPS system allows users to send their location to the rescue services if immediate help is required. To make a safe operation during power lacking, the system includes a battery backup unit for the people's safety in extreme danger conditions.

The three-level alert system improves safety by making early warnings and improve emergency responses. At Level 1, the system activates an alarm

when the water level reaches a certain threshold level, warning the nearby residents. If the water level is rising, Alert Level 2 is reached, where an SMS notification is sent to helpline services automatically, and the alarm remains active. At Alert Level 3, the system initiates an emergency call to the rescue authorities, making that urgent response action are taken. Additionally, an emergency button allows people to send their GPS directly to rescue teams if they are caught in flood and unable to evacuate the place in time.

The AquaVigil system follows a structured workflow to ensure efficient operation. Water level sensors continuously transfer the real-time data to the Microcontroller, which processes the input and gives the appropriate alert level. Based on the severity of the flood, the alarm, SMS, and call functions are activated. If the emergency button is pressed, the system immediately sends GPS coordinates to helpline services to make a smooth helping. The LCD screen provides live updates on flood levels, spreading the awareness for users. The system is designed with a power backup, allowing it to function even during electrical failures.

This system architecture is highly useful, extensible, and efficient for implementation in flood-prone area. By adding automated alerts, real-time monitoring, and GPS-based emergency tracking, AquaVigil makes faster disaster response, improved coordination, and reduces the amount of loss of life.

VI. RESULTS

By implementing the AquaVigil hardware system which has significantly lessened the number of lives which were taken away by flood. The AquaVigil Hardware System is tested under continuous flood conditions to examine the hardware system's performance in real-time flood detection, generating alerts, and emergency response. The system successfully detected the rising water levels at certain threshold levels which were set and generates the appropriate alert mechanisms. The three-level alert system behaves as expected. At Alert Level 1, when the water level has reached the certain set threshold, the alarm is activated, giving an early warning to nearby residents. At Alert Level 2, when the water exceeds the critical threshold, an SMS is automatically sent to helpline services, making timely

awareness for emergency response services. At Alert Level 3, in severe conditions, the system automatically makes an emergency call to the authorities, and the alarm is being generated non-stop.

In addition to the automatic alert mechanism, the emergency button with GPS tracking worked as expected, allowing users to manually generate an emergency signal and send their real-time location to emergency services. This feature adds another extra layer of security, making sure that individuals in help can quickly contact the emergency services. The LCD display successfully shows real-time status updates, making clear communication of system activity and improving timely awareness for the people affected by flood.

The system is evaluated based on several performance parameters, including responding time, accuracy, reliability, and communication efficiency. The response time of the system is measured from water level detection to alert generation, was consistently under 3 seconds, making real-time responsiveness. The accuracy of the water level sensors was recorded at 99%, minimizing the false alarms and making sure of precise alert activation. In terms of reliability, the system continued to function during the power failures due to its battery backup hence, maintaining uninterrupted operation. The SMS and call operations were tested on multiple network providers and achieved a message delivery with a success rate of 98%, showing its efficiency.

A comparative analysis with existing flood detection systems displays the improved features of AquaVigil, such as multi-level alert mechanism, incorporated GPS tracking system, and an emergency button. Unlike the systems which only depend on alarms, AquaVigil makes sure that both audible warnings and direct communication with emergency services, increasing the likeliness of timely alerts. This feature which is set makes the system highly effective in reducing the loss of lives and property damage in flood-prone areas.

User feedback during controlled testing was positive. Participants found that the system is useful and effective, with minimal false alarms into disaster response systems. Which helps many of us to rescue ourselves.

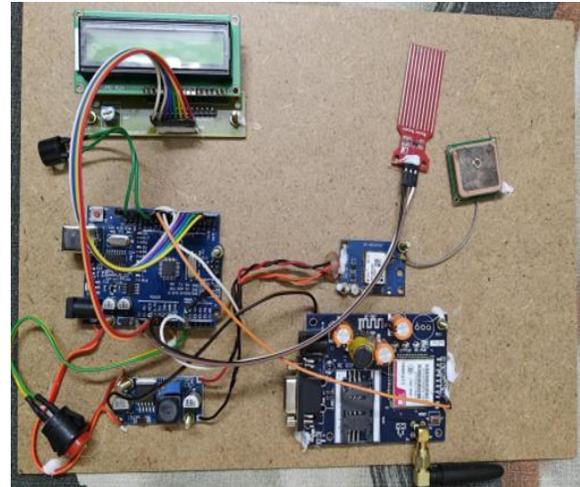


Fig. 3. Working Model

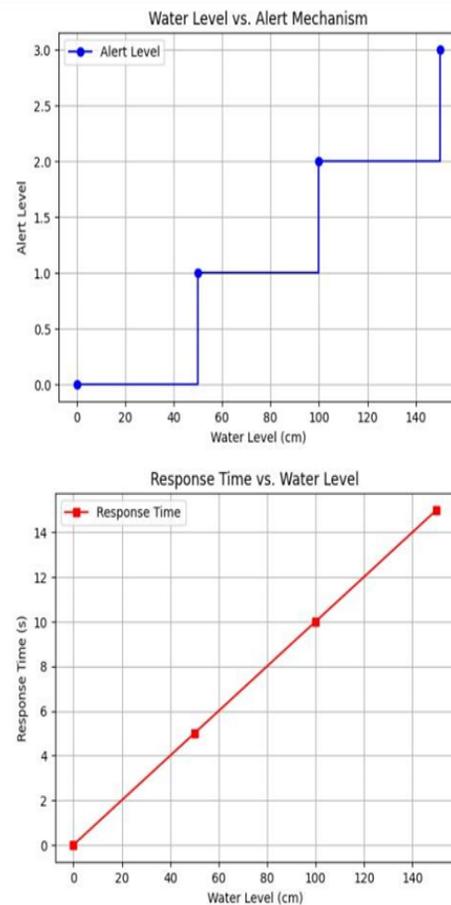


Fig. 4. Efficiency of AquaVigil Hardware System

The test results validate the effectiveness of the AquaVigil Hardware System in providing timely flood alerts, emergency communication, and GPS-based distress signaling. The system's high accuracy, low response time, and reliable communication

infrastructure make it a practical and scalable solution for flood-prone regions. Future improvements, such as AI-based predictive analytics and cloud data integration, could further enhance its functionality and impact, making it an even more robust tool for disaster management and response.

VII. CONCLUSIONS AND FUTURE WORKS

The AquaVigil Hardware System has been designed and developed to provide an effective and useful real-time flood monitoring and emergency response system. This system plays a crucial role in controlling the flood-related risks, minimizing the loss of life, and improving overall disaster preparedness. By implementing multiple alert levels, the system promises that both individuals and emergency response teams receive timely warnings and the action is taken accordingly. The implementation of an alarm system, SMS alerts, and automated emergency calls improve the efficiency of communication during critical floods.

Furthermore, the LCD screen provides real-time flood water level, while the emergency button with GPS tracking promises that individuals who got into trouble can be quickly located and rescued. The device has been designed to function efficiently under different environmental conditions, including the conditions for power backup to ensure uninterrupted function of the device. The involvement of automated communication with nearby helpline services further strengthens the system's ability to reach out the affected communities. With its adaptable design, immediate response capabilities, and user-friendly operation, the AquaVigil Hardware System presents itself as a good and effective tool for flood detection and emergency management. The successful implementation of such a system can gradually reduce response times, improving awareness, and save lives. This project serves as a model for the future advancements in disaster response technology. This demonstrates the importance of smart and automatic flood management solutions for the people out there getting affected by floods.

To further improve the functionality of the AquaVigil hardware system, we can incorporate it with an AI which can detect the rising water levels by analyzing the current water level. Solar powered back-up can be fixed in the device to make sure that the device runs even when there is no power. In future we can develop a software where the hardware is connected through it. In the software when there are floods, we can show the users where the nearest safe locations are, the historical flood data, the safety measures which are to be taken at the time of floods, the camp spots and the resources each camping spot contain,

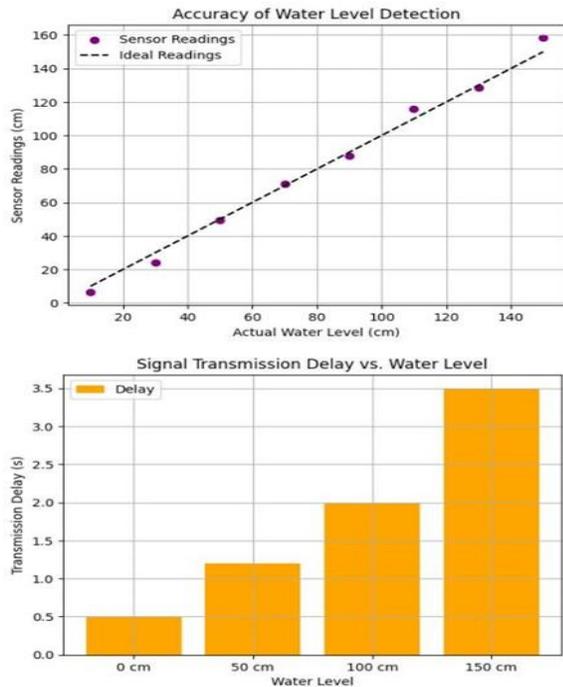


Fig. 5. User Review on how accurate the system works

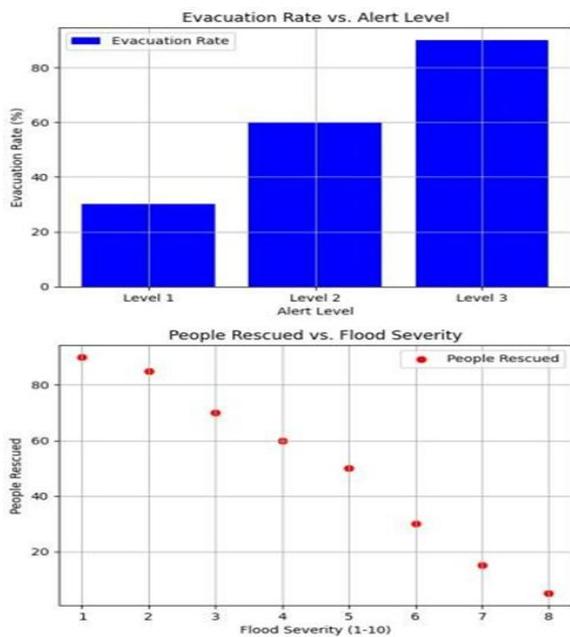


Fig. 6. User Review on how accurate AquaVigil works

such that the people can be shifted to particular camp spots accordingly.

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