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Development of an IoT Based Prototypical Real Time Flood Monitoring System for the Flood Prone Region "Anambra West," Nigeria

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***Abstract* - Flood prediction is appealing in the global scheme of things among the technologies that enhance research growth and the reality of human existence today. This work presents the development of an IoT based prototypical real time flood monitoring system for a Flood Prone Region "Anambra West," Nigeria. The study region lies approximately between the latitude 6°20'N to 6°40'N and longitude 6°30'E to 6°50'E. The research area is among the regions most vulnerable and highly susceptible to devastating flooding in the South Eastern part of Nigeria and, poses significant threats to lives and livelihoods. Accurate real time variation measurement of water levels, flood current and territorial events is crucial for effective flood risk management in this dynamic environment. We aimed at developing an efficient and reliable real time flood monitoring system combining IoT with ultrasonic sensors. To identify the safe mode and the vulnerability state of the three research communities, an adapted technology of threshold methodology is established using Esp32, boxes, pipes and joints, wooden platform, LCD i2c, USB power cable, water container, Sim modules, and Ultrasonic Sensors to develop a hardware system for investigation of water levels at Mmiata, Ifite Ogwari, and Umueje in Anambra West. The developed prototypical real time system monitors water levels at the three mentioned communities with the help of the S1, S2, S3 and is programmed to send What's App messages and SMS alert to the Admin and to the registered community members. This real time system continues to upload and update on the state of the art of flood surge, and food receding in the three communities. The study helps to fine tone the flood extent and to equip with better planning for risk reduction and management during flooding period.**

Keywords: Susceptibility, devastating floods, vulnerable, Food prediction, water Level, Change detection, real time update, Flood surge, Flood Receding.

I. INTRODUCTION

Flooding remains one of the most devastating natural disasters, exacerbated by climate change, urbanization and inadequate monitoring systems.

Flood is defined as the inundation of substantial volumes of water onto normally dry land, and is regarded as one of the most severe types of natural disasters. It is primarily triggered by heavy rainfall, the overflow of rivers or lakes, the absence of proper drainage systems, and the rapid melting of snow or the impact of storm surges resulting from tropical cyclones or tsunamis in coastal areas. Floods can vary significantly in magnitude, ranging from a few inches to several feet of water (Ryberg, 2012).

Flood monitoring system utilizes computer technology, database technology, communication technology, and sensor technology. Early warning of impending flooding could save lives and reduce extensive property damage. Predicting potential flood disasters and providing scientific information is necessary for effectively preventing of flood disasters. (Renkeer, 2025).

There has been sharp increase in demand for flood monitoring systems. Floods are of five common types: river flood, coastal flood, storm surge, inland flooding, and flash flood (Holdeman, 2023). Some floods manifest suddenly and recede rapidly, while others develop gradually over several days or even months, owing to variations in size, duration, and affected area (Yang *et al.*, 2021).

Factors contributing to flooding in Nigeria include poor or non-existent drainage systems, inadequate waste disposal and management, unregulated urbanization, weak implementation of planning laws, and corruption, as explained in The Conversation Africa (Echendu, 2022) .

The consequences of flooding can be severe, leading to hardships, damage to crops, loss of life, and extensive destruction of both private and public property. It constitutes a

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setback to development because of its wide-ranging impacts that can derail decades of progress and development. The economic, environmental, social and cultural impacts have also risen significantly, highlighting the necessity for researching on approaches to manage flood risk (Njoya *et al.*, 2022).

Inarguably, flooding is a multiplex issue because of the various causes, types and impact. Nigeria principally experiences fluvial and pluvial flooding. Fluvial flooding also known as river flooding happens when a river overflows its banks due to excess rainfall or snowmelt over a period. Pluvial flooding occurs when heavy rainfall leads to flooding even in the absence of a close by water body. Flooding impacts the global goals of sustainable development as a result of its criss-crossing impacts that range from social, economic to environmental. Population growth and increasing vulnerability are drivers of change that worsen flood impacts (de Bruijn *et al.*, 2022). The timely information of the flood occurrence and impacts are helpful for the government to act immediately to the emergency response. The rapid estimation of the spatial extent of flooding over large areas provides a key data source for assessing the disaster risk and spatial planning (Dumitru, *et al.*, 2015). Remote sensing and satellite imagery plays an important role in monitoring and flood mapping (Li, Y. *et al.*, 2018).

Given the devastating effects of floods, flood monitoring system become crucial. The management process encompasses several phases, including preparedness, prevention, response, and mitigation. The preparedness phase focuses on minimizing damages through prompt and efficient response strategies, such as prediction and risk zone identification, which can be facilitated by the development of an early flood detection system. The prevention phase involves early forecasting, monitoring, and the formulation of contingency plans before or during an event. The response and mitigation phases encompass activities undertaken after a flood disaster, such as damage assessment, controlling floodwater movement, and relief management.

Moreover, it is another inevitable job to resist the devastating flood if there is a possible method to inform the population living around the area, through the appropriate and proper way in real-time. To date, detecting variations of water levels in a variety of flood zones is widely utilized as sensor technologies to share data with inhabitants (Choubin, 2019).

II. LITERATURE SURVEY

Clearly meteorological complements broader data sets and predictions, offering a laser-focused understanding of what's happening in a specific area.

(Merlo, 2023) successfully developed a Cloud Computing for Data Integration system. Cloud computing plays a pivotal role in flood monitoring by enabling the integration of diverse data sources from remote sensors, satellite systems, and predictive models. Cloud platforms facilitate real-time data processing and seamless communication between stakeholders, including government agencies, disaster management organizations, and affected communities. These platforms also support scalable flood monitoring networks, allowing systems to be expanded rapidly in response to increased flood risks or new vulnerable areas.

(Schumann, 2021) In his work applied Social Media as a Supplementary Data Source. Emerging systems are increasingly incorporating social media data to enhance flood monitoring and response. Crowd-sourced information from platforms like Twitter, Facebook, and Instagram can provide real-time flood reports and support early warning systems. Integrating social media with automated flood detection systems improves situational awareness, particularly during large-scale events where official data may be delayed. (Thekkil, 2019) developed a real time Wireless sensor network for early flood detection and control monitoring system, designed with a function of real time monitoring with guaranteeing connectivity in low cost. This system consists of CMOS image sensor to capture image for monitoring and Zigbee network and GSM network to transmit the images. Transmitted images are compared with already stored images with the SIFT and BRIEF algorithm and the decision is taken by comparing the ranks. If it alerts danger, alarm will be beeped. However, the work did not consider nor address the limitations associated with CMOS sensors such as questionable sensitivity, noise, power consumption, voltage operation, speed imaging and dynamic range challenges.

(Yumang *et.al*, 2025) developed a standalone flood water level monitoring system for the community in Kahilom Street Pandacan, Manila. The system mainly consists of solar panel sensor with Arduino Uno, GSM shield. Early warning system is consisting of PVC pipe with three LED and the SMS alert. Mainly three sensors are used to detect the water level, when water touches the first sensor first indictor indicates the water level and so on. Solar panel sensors have several limitations when used for flood monitoring. These include inaccurate readings due to sensor sensitivity to water, limited detection range, and potential for damage or malfunction during flooding. Additionally, relying solely on solar-powered sensors can be problematic in flood-prone areas due to the potential for power outages and sensor damage.

(Guesmi, 2017) proposed a real time model based on wireless sensor network for flash flood and torrents monitoring and the warning system which consists of wireless

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smart sensors to measure hydrological data. The proposed system determines the expected reaching time, affected zones and danger intensity level based on hydrological and geographic data and initiates the warning system. Author have used LabView simulation tool as simulation platform in which data processing is based on cRIO data acquisition system. The deployed system consists of precipitation sensor, flow velocity sensor, flow level sensor, camera sensor and a temperature sensor connected to a programmable node via a data acquisition board. NI WSN-3212 and WSN-3202 with NI WSN-3212 visual sensors are used. NI-WSN9795 module is installed in cRIO chassis as a gateway. St Venant equations or shallow water equations is used for flood propagation. The proposed model warns communities of the incoming flood to protect people.

Having reviewed many works in the same study context and looked into the contributions and limitations, we have discovered that while meteorological data can predict potential flooding, real–time flood monitoring provides current, localized information that can help authorities take immediate action.

Meteorological also do complements broader data sets and predictions, offering a laser-focused understanding of what's happening in a specific area. The real time flood monitoring system serves as a fundamental pillar of resilience against the unpredictable elements of nature and that no matter how important other flood monitoring approaches could be, IoT is among the most vital communication systems that serves the general public purpose on information circulation and this nature of IoT cannot be easily discarded now and in research ages to come , therefore, this research work is focused on the development of an IoT based real time flood monitoring system for a 3 phase communities in Anambra West.

III. PROBLEM

Meteorological data can predict potential flooding but is too complicated and is not reliable in providing current, localized information that can help authorities take immediate action. Again; Anambra West is primarily situated in a low-lying floodplain of the Lower Niger Basin, making it one of the most flood-prone regions in Southeastern Nigeria. The area comprises numerous river channels, including tributaries of the River Niger and Omambala River, which serve as the major hydrological features influencing seasonal and flash flooding patterns.

IV. METHODOLOGY

We have developed a flood monitoring and early warning system using IoT and ultra sonic sensor nitty-gritty in three communities in Anambra west, Nigeria. The system mainly consists of three Esp32, ultrasonic sensors, Sim module and web-monitor to create an early warning system. Ultra-sonic sensor is used to measure the water level to monitor flood at each station 1, 2, and 3. Solar panel operated microcontroller is connected with ultra-sonic sensor and GSM module. Web-based program was adopted using python IDE. As the risk level increases the notification delivery of the SMS and What's App messages also increases. The Esp32 is ideal for Iot-based flood detection systems due to it's processing power, built-in Wi-Fi/Bluetooth, and low power, acting as the core to read sensors (like ultrasonic for water level, rain, rain sensors) and send real-time alert via SMS/apps/cloud when thresholds are crossed, enabling early warnings to protect communities. These systems offer remote monitoring, data visualization, and automated responses (like opening valves), improving disaster management sufficiency and resilience in flood –prone areas.

V. SYSTEM DESIGN

The system is made up of one central controller (ESP32), and three other controllers that are all synchronized with the server (the central controller).

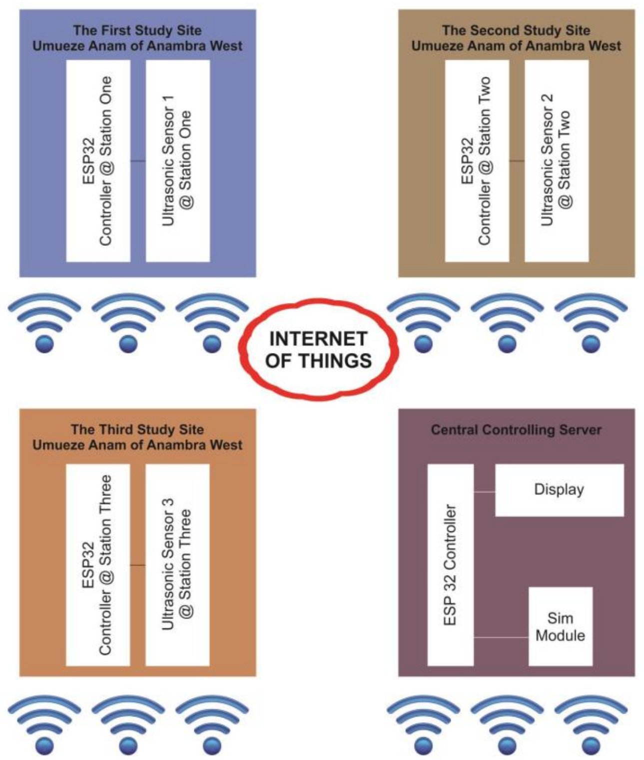

Figure 5.1: The diagram of an IoT based real-time flood monitoring system for a three flood prone communities in Anambra West Nigeria

This creates opportunities for logins and as well flood risk information dispatch program possible. Here the central controller is programmed to function as a central server

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where as the other 3 controllers are programmed along side with an ultrasonic sensor respectively installed at the 3 flood prone communities in Anambra West know as “Mmiata, Ifite Ogwari, and Umueje” for a continuous monitoring of water levels.

VI. SYSTEM SIMULATION

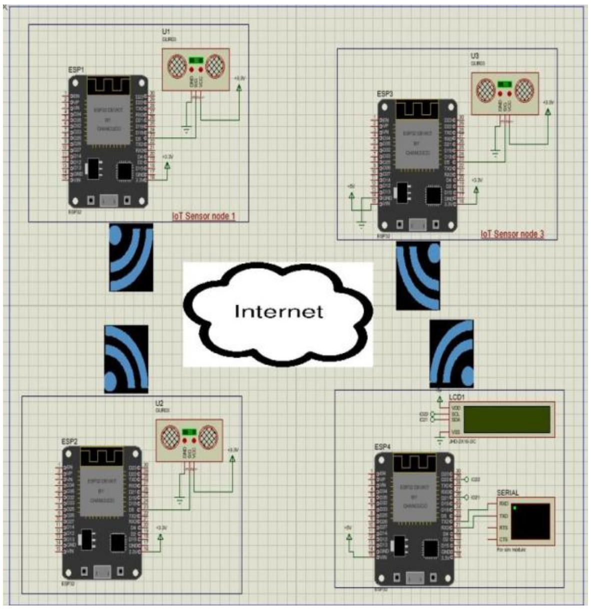

Figure 6.1: Simulation of an IoT Based Real time prototypical Flood Monitoring System for Three Communities in Anambra West

VII. VALIDATION AND IMPLEMENTATION

In this research, the use of integrated development environment (IDE) program and ultrasonic sensors was the orchestrated scenarios at different flood monitoring stations which are “Nzam local government Area, Ifite Ogwari and Umueje” of Anambra west Nigeria.

Figure 7.1: Validation and Hardware Implementation of the IoT Based Real Time prototypical Flood Monitoring System for Three communities in Anambra West Nigeria

VIII. RESULT AND DISCUSSION

8.1 Dash board/Flood monitoring Server

Sensor reading shows moderate and normal at the first scenario and update. This indicates that the research zones are not yet in danger of flooding and however, are safe to go about their normal businesses within the region. Again; the Flood Monitoring Server offer real-time data and insight showing flood or water levels, and is used to make the choice of flood threshold due to sensors at work at different stations. The flood monitoring server serves as a connection between the users’ login and the other communication apparatus.

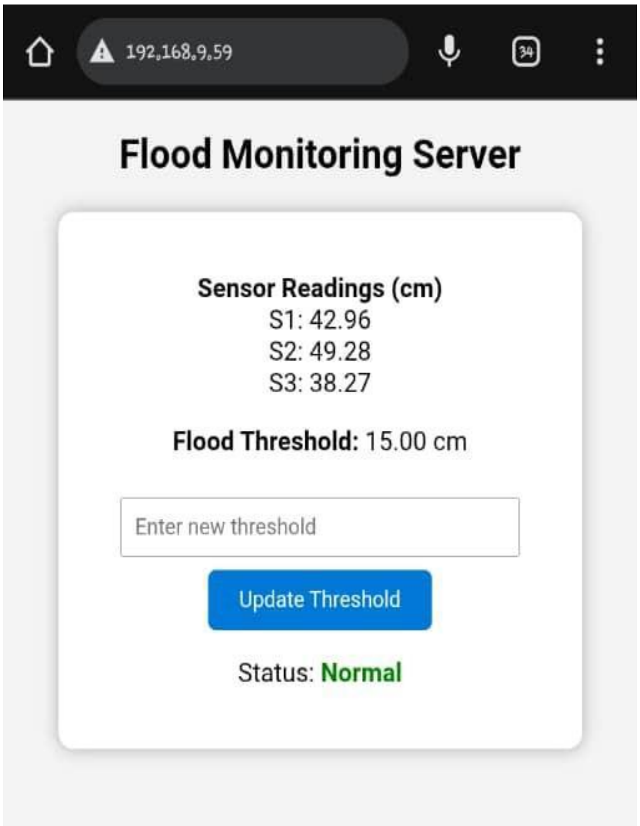

Figure 8.1: The Flood Monitoring Server Showing the Current Status

8.2 Flood Monitoring Server

Figure 8.2 Sensor reading and What’s App messages shows flood likelihood and surge in this scenario and update. This indicates that the research zones are likely going to be in danger of flooding and therefore that the inhabitants should be ready to vacate the flood prone region to avoid vulnerability. Again; the Flood Monitoring Server offer real-time data and insight showing flood or water levels, and is used to make the choice of flood threshold due to sensors at work at different stations. The flood monitoring server serves as a connection between the users’ login and the other communication apparatus.

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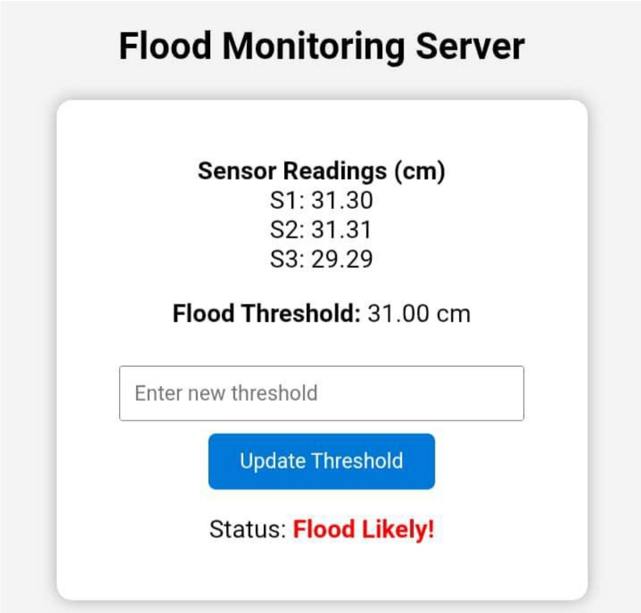

Figure 8.2: Flood Monitoring Server

8.3 Display unit

The display unit is a bale the managers to read the sensor 1, sensor 2 and sensor 3 login in centimeter and, also indicates the flood thresh hold.

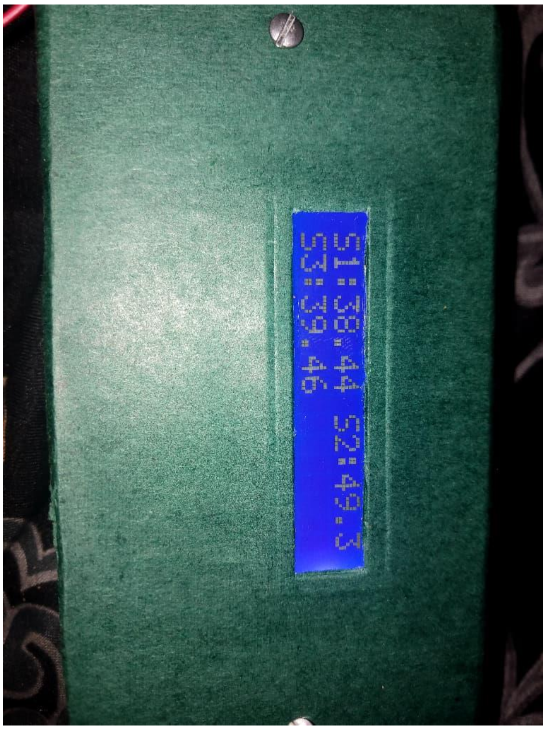

Figure 8.3: Display unit

IX. CONCLUSION AND FUTURE SCOPE

The sensor reading at the first station which is situated at Nzam local government Area of Anambra West, showed a Moderate risk all through while the sensor reading at the station two which is situate at "Ifite Ogwari" showed a high risk and high vulnerability with about 2 millimeter above that of Nzam. Additionally, the reading at station two which situate at Umueje showed the highest flood risk level with 4.3 millimeters topping that of Nzam. The study helps to fine tone the flood extent and to equip with better planning for risk reduction and management during flooding period. The system is highly educative and proffers a lasting solution to the long time flood menace in the region.

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