DAM MONITORING AND ALERTING SYSTEM

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Abstract*—A dam is a barrier constructed across a river to control the flow of water. Dams are used for harvesting energy and further utilizing this energy for generating hydroelectric power. Dams are also used for protection against flooding conditions by controlling the flow of water in the river. Apart from this dams can release water to the river to facilitate agricultural activities like irragation. The majority of the dams are still being manually controlled which is a very inefficient and time-consuming way of controlling dams. Due to this, the mismanagement of dams happens which can lead to devastating damage. This can be evident from a few recent cases of dam failures like the Dhauliganga dam failure case of 2021, the Tiwari dam failure of 2019, and the Uttrakhand dam failure of 2013 where dam failure lead to flash floods causing severe property damages and loss of many lives. To solve this issue an IOT-based dam monitoring and alerting system has been proposed that can reduce the human intervention from the existing dam control system thereby making the system more efficient, and more accurate hence reducing the chances of dam failures. The water level of the river is continuously monitored using ultrasonic sensors and this real-time data is used by the decision algorithm of the system to make decisions for controlling the dam. Once this data is collected node-red is used to represent this real-time data using graphical representations on a web-based dashboard. Also node-red is used to further send the sensor data to thingSpeak. This will allow the dam operator to remotely monitor the dam working. The system uses IFTTT to send alerts to the dam operator whenever a flood condition triggers so that possible measures can be taken to control the situation. We have used a machine learning model in our system to categorize the water level of the river.

Keywords*—Dam failures, Flash floods, IOT, NodeRed, ThingSpeak, IFTTT, Ultrasonic sensor etc.

I. INTRODUCTION

IoT in disaster management helps in improving disaster management efforts by providing real time monitoring, data collection and communication capabilities. It also allows alerting the concerned authorities at an early stage, and rescuing people affected by disaster, which results in saving lives, money, and resources. IoT devices have the potential to transform the reactive disaster management processes into predictive processes. IoT sensors can detect changes in the environment which allow early warning systems to provide alerts to the residents in the nearby affected areas. Moreover, IoT devices such as drones can be used for rescue operations in disaster affected areas, enabling concerned authorities such as rescue teams to save lives and reduce casualties.

An effective dam monitoring and alerting system has a good algorithm that takes all the parameters under consideration and based on that controls the dam more efficiently and with more accuracy. It allows the users to monitor the real-time water level, along with some other important factors to reduce the chances of damage. It also uses alarms and gate control for proper dam automation. The system also collects real-time data from the dam water level and water body level so that it can accurately estimate when the water level will cross the flood condition. Nowadays dams are controlled manually, due to which dam gateways are not operated timely which can cause issues for the nearby residents like unavailability of water for irrigation or floods. The target customers for the dam monitoring and alerting system are the residents residing in the nearby areas.

Dam monitoring and alerting systems can be used to ensure public safety by detecting any potential problem with the dam thereby reducing the chances of failure. It will also reduce the role of manpower in dam operation thus increasing the efficiency of the system and making the availability of water for irrigation easier for the nearby residence and also use for cost reduction as it can detect problem at early stages and prevent potential damages

The system uses IOT sensors to measure the water level at two positions i.e. at the upstream and downstream of the dam. Further this collected data is used to categorize the water level into one of the possible three levels namely loop level, irrigation level or flood level. Once the data from the two locations is categorized these are used to make the final decision about whether to open or close the dam. This can

help in automating the dam working by continuously monitoring the water level hence reducing chances of flood and allowing water for irrigation to the residents of the nearby area.

Some of the contributions of our dam monitoring and alerting system are as follows:

(1) This system uses an efficient algorithm undertaking both upstream water level and downstream water level to operate the dam therefore it reduces the amount of manpower required for the working of the dam as the dam gates can now be controlled automatically.

(2) This system helps to trigger the flood condition before it comes to happen and before it, it will alert all the nearby residents who can be affected by the flood and email all the concerned authorities like NDMA, police, etc. to take immediate action to save the people and their property.

(3) This system uses Node-red and ThingSpeak to monitor the water level downstream as well as upstream of the dam at run time and push that data to the cloud, which in the future helps us to predict the critical water levels that can result in floods or water levels needed for agricultural activities, with this we can train our model to predict with the highest accuracy to determine the flood at the earliest stage.

The Introduction to the problem is discussed in Section I. Section II focuses on the summary of past related works. Section III focuses on the proposed method used for our system. Further, Section IV discusses the flow of our systems decision system, hardware and software setup. Section V highlights the results obtained by our system and Section VI discusses the conclusion. Lastly, we have covered references in Section VII.

II. LITERATURE REVIEW

In the paper [1] Dr. Nagesh Shivappa et al. discusses the importance of dams in water resource management and the need for appropriate monitoring systems to ensure their safe use. The paper proposes a system capable of controlling the health of dam by using IoT to improve dam monitoring and water flow control. The proposed method uses microcontrollers, sensors and control valves to automatically control water distribution during crises using statistical data from the environment. The system uses sensors to measure various river parameters and transmits this data to a server for further processing and analysis. The system also provides real-time alerts and notifications to authorities and users to take appropriate action in the event of a crisis. The article concludes that the proposed system can significantly improve the efficiency of dam management system..

In the paper [2] Rabiya Basreen et al. propose a system that uses IoT to monitor the real time water level in dams and alert the authorities whenever the water level crosses a critical level. The system consists of sensors that are placed in different locations of the dam to measure the water level and send the data to a microcontroller. Further the microcontroller processes this data sends it to the cloud server. The cloud server then analyses it and based on it send alerts to the authorities for any critical condition. The system also provides a web bases user interface for the dam operator to monitor the dam working and also receive alerts from the system.

In the paper [3] S. Janani et al. discusses the importance of India's dam management system which is essential for water supply, power generation and flood control. This article highlights the need for an automated dam management system toreduce the risk of life due to any disaster. This article proposes to automate a dam system using an Arduino-based automation system, ultrasonic sensors, a GSM module, and motors. The proposed system will collect real-time water level using ultrasonic sensor and based on this the system provide alert to the people living on the shore and also control the dam gate . The article suggests that timely warnings to residents of nearby locality can reduce loss of life.

The system proposed in this paper [4] by Noel Mathew Jacob et al. is an IoT-based dam monitoring system aimed at preventing disasters and effectively managing water resources. The system involves remote monitoring and control of dams using real-time data of various river parameters. This data can be remotely accessed by the dam operator for the purpose of dam control. The system provides three levels of warning (blue, amber and red) depending on the capacity of the dam. The proposed system also demonstrates how drought can be avoided by balancing excessive and insufficient water levels in the reservoir. The system is designed to make the process of dam monitoring and controlling system more efficient.

Article [5] by S.Rajapriya et al. proposes the use of an IoT-based information system to monitor dam safety and water resource management. The system consists of various sensors such as water flow, water level, vibration and ultrasonic sensors which transmit data wirelessly to a microcontroller. The microcontroller processes the data and displays it on the LCD screen. The system uses IoT to wirelessly transmit this data over long distances and this data can be publicly accessed using a web application. This system provide real time water level monitoring that can be used to prevent flooding and other damage caused by rapid water changes and also help in more efficient water management.

The system proposed in article [6] by KAVITHA.R, et al. is designed to address the issue of water scarcity and need for effective ater resource management. The system uses ultrasonic sensors to measure the water level in real-time

and send alerts to concerned authorities when the water level crosses a certain threshold. A web based dashboard allow proper monitoring of the dam system.

III. PROPOSED METHOD

The proposed systems will concentrate on four major areas as follows

A. Water Level Monitoring

The proposed system will measure the water level of the river (downstream) and water level of the water collected by the dam (upstream) in real time using ultrasonic sensors and this data will be used by the system for early prediction of flood conditions in the water body.

B. Flood Alerting System

The system will use the real time water level data to predict any future possibility of flood. Whenever there will be an abnormal water rise due to heavy rainfall or glacier melts that can lead to flood then the system will send alerts about this to the concerned authorities via Email and to the local residents living downstream via SMS.

C. Gate Control (Automated)

On the basis of the water level data of upstream and downstream the proposed system will automatically open or close the dam gate. This will help in reducing manual intervention and hence make the process of gate controlling more efficient by reducing the possibilities of human error.

D. Agricultural water supply

Since the proposed system has automated the dam gate controlling based on the water level of upstream and downstream it will open the dam gate as soon as the water level in the downstream goes below irrigation level and hence the residents of the downstream will get sufficient water supply for agricultural activities whenever required.

IV. IMPLEMENTATION

A. Flow Chart

The system will take the current water level as input from upstream and downstream using the ultrasonic sensors. This input will be passed to the decision algorithm of our system as shown in Fig 1. The output decision is used by the system to control the working of the dam.

B. System Design

The software requirements for our proposed system are as follows

1) *Node-RED* : It is an open source programming tool built on Node.JS. It is used for interfacing IOT devices like arduino with apis and other online services. It will be used in our system for interfacing our hardware system with ThingSpeak. It is also used for creating a user friendly and interactive dashboard that is used to display the data and pop-up notifications for alerts. The node red flow for our system is shown in Fig 2.
2) *Arduino IDE* : It is an open source platform that provides a simple interface for programming arduino boards and uploading code on them.
3) *Tinkercad* : It is an online prototyping tool that provides a user-friendly interface with drag drop tools to stimulate hardware devices. Tinkercad was used by us to create a virtual circuit for our system as shown in Fig 3.
4) *ThingSpeak* : It is an open source IOT cloud platform that allows the user to collect, analyze and visualize data collected from devices. It was used in our system to store the upstream and downstream water level data in real time.
5) *IFTTT* : It stands for “If This Then That” and it has been used to send alert mails to the authorities and rescue teams when an alert is triggered by ThingSpeak based on the real time water level data.

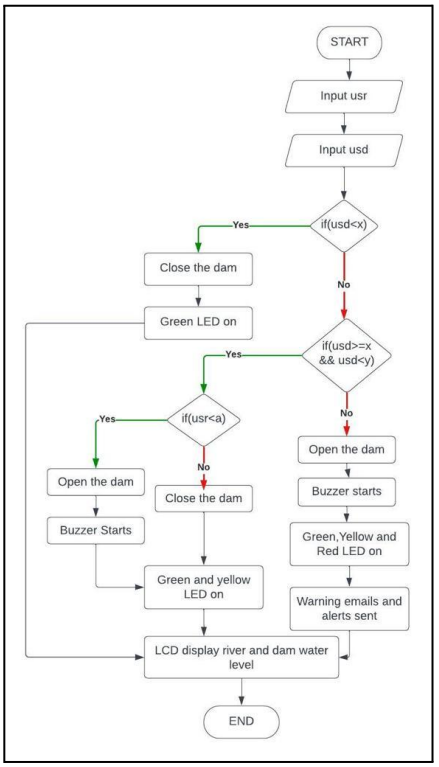

Fig 1

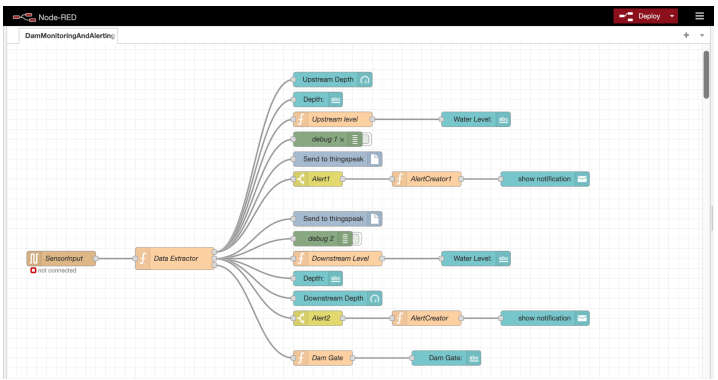

Fig 2: Node-Red flow

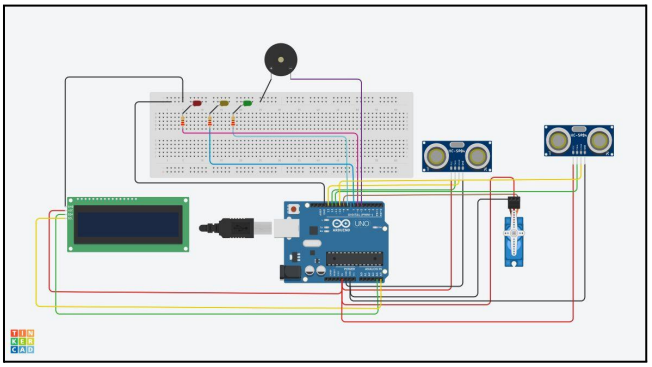

Fig 3: Circuit Diagram

The hardware requirements for our proposed system are as follows

1) *Arduino UNO* : It is a microcontroller board that is based on the ATmega328P microcontroller. It is used as the microcontroller for our system and is used to control other hardware devices of our system.
2) *Ultrasonic Sensor (HC-SR04)* : It uses high frequency sound waves to detect objects and measure distances. It has been used in our system to continuously measure depth of water level upstream and downstream at regular intervals.
3) *GSM-900A Module* : It is an electronic device that is used to enable communication between devices and the GSM network. GSM module has been used in our system to send alert messages to the residents downstream whenever a flood condition triggers.

Some other hardware devices are also used in our system like buzzer for alerting at trigger conditions, led lights for representing different water levels, lcd used to display water levels and servo motor for controlling dam gates. The hardware setup for our system is shown in Fig 4.

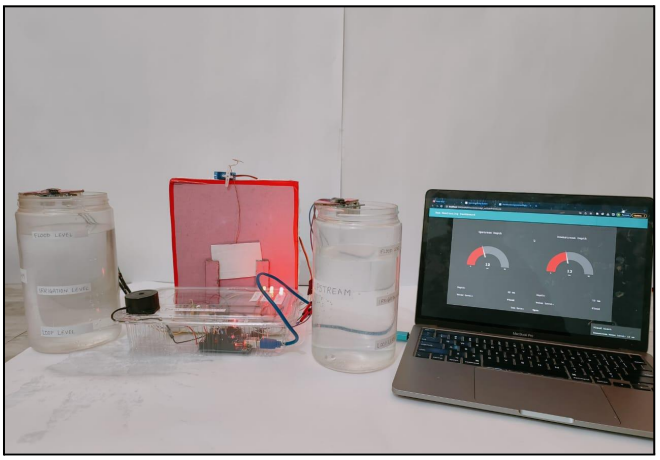

Fig 4a

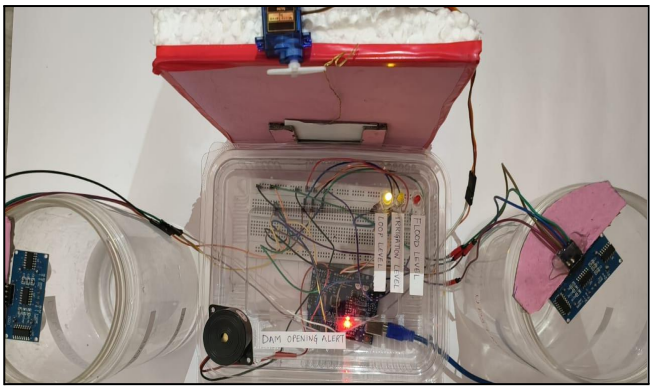

Fig 4b

V. RESULTS

In the prototype of our system the upstream and downstream are divided into three levels namely loop, irrigation and flood and based on this three scenarios can arise that are demonstrated as follows

A. Downstream lies in loop level

In this case if the upstream lies in irrigation level then the servo motor will open the dam gate and water will be released. Else if the upstream lies in loop level then the servo motor will not open the dam gate.

B. Upstream reaches the flood level

In this case the flood condition has triggered. Firstly alert mails are sent to NDMA, police stations and the rescue teams and simultaneously dam gates are opened using servo motor. A sample alert mail is shown in Fig 7.

C. Downstream reaches flood level

In this case the chances of floods are very high so the system sends alert SMS to the downstream residents so that they can take the proper safety measures. A sample alert SMS is shown in Fig 8.

Here the boundary values for deciding the category of water level is done using a machine-learning model that uses decision tree classifier for classification. The analysis of the dataset was done using microsoft powerBi and is shown in Fig 5. Also the performance measures for the trained machine-learning model is shown in Fig 6.

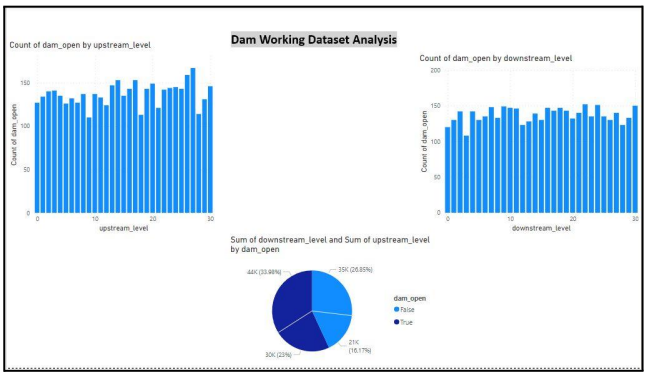

Fig 5: Dataset Analysis

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Classification Report:
              precision    recall  f1-score   support

       False       0.87      0.82      0.84       443
        True       0.82      0.87      0.84       408

    accuracy                           0.84       851
   macro avg       0.84      0.84      0.84       851
weighted avg       0.84      0.84      0.84       851

Confusion Matrix:
[[364  79]
 [ 55 353]]
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Fig 6: Performance Metrics

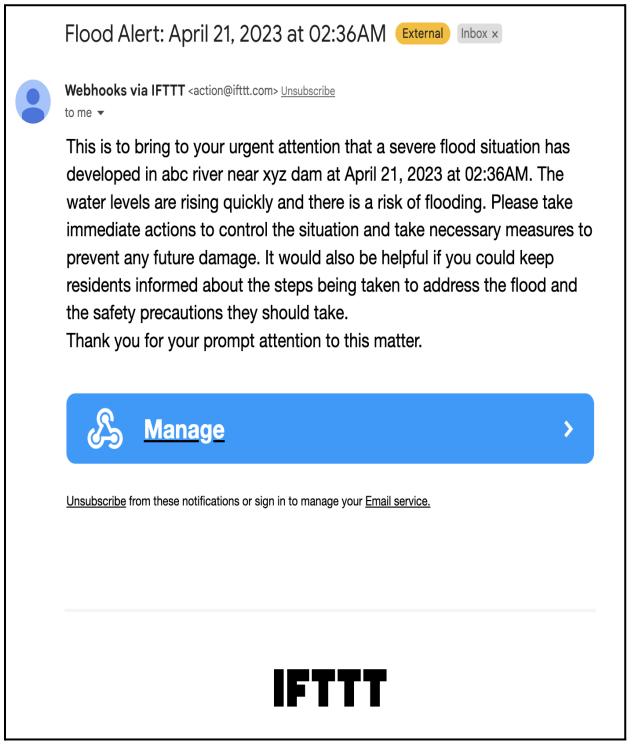

Fig 7: Alert Mail

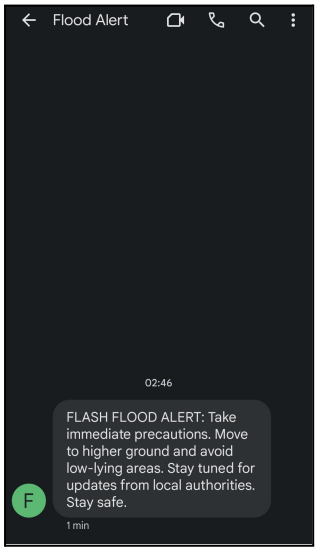

Fig 8: Alert SMS

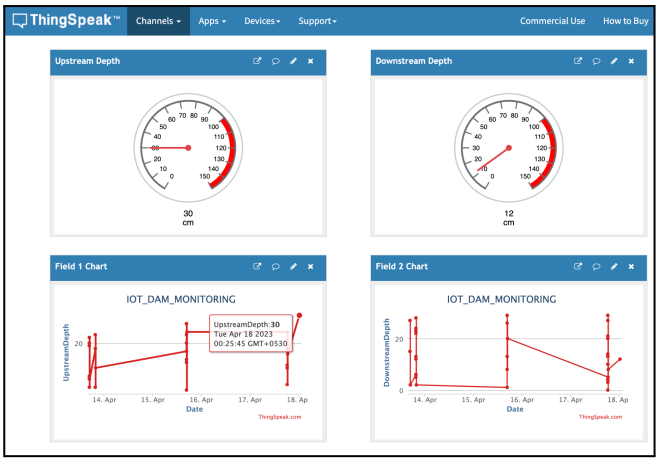

Fig 9: ThingSpeak

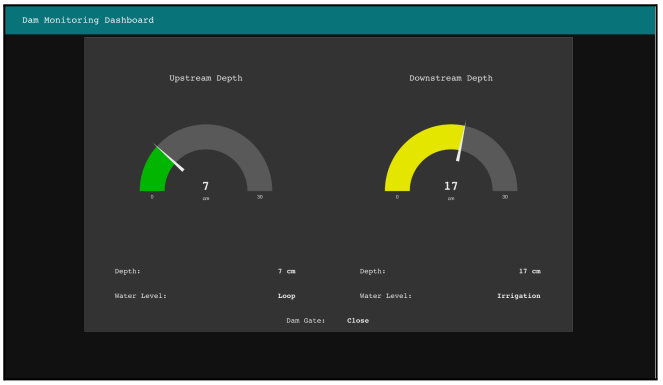

Fig 10: DashBoard

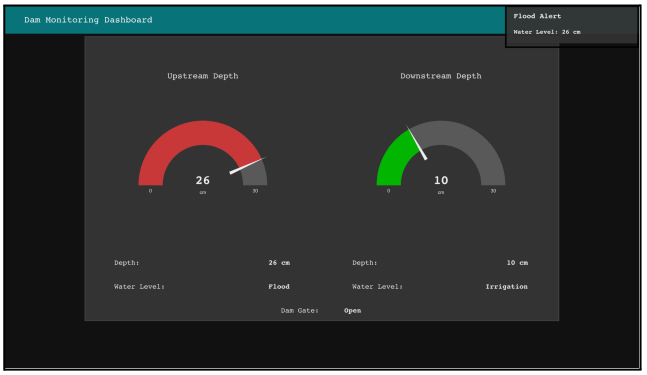

Fig 11: Flood Condition

VI. CONCLUSION AND FUTURE SCOPE

The proposed system makes use of IoT to efficiently monitor the dam system and give alerts whenever required. The system is able to successfully measure water levels upstream and downstream in real time.The system makes it easier to control dam gates based on the system's decision system rather than relying on manpower and hence makes the process of dam controlling more efficient. The system is also able to alert the authorities and nearby residents about flood conditions being triggered. Also automated dam control allows the residents to receive water for agricultural activities whenever required. According to our tests, the system has shown promising results when faced with the typical problems encountered by other dam monitoring and alerting systems. All the test cases work properly and all the

hardware components respond properly during trigger conditions.

In future, it is aimed to take into consideration natural phenomenon like rain for dam monitoring. We will try to build a machine-learning model to predict chances of rain and further use this prediction for controlling the dam working. This will allow us to further increase the efficiency of system and further reduce the chances of floods due to dam failure or excessive water overflow in the river.

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