



# Early flood warning system using ESP micro-controller

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**Abstract** – The climate is changing as a direct result of global warming, which is causing a range of extreme weather events to take place, including floods and intense downpours. The floods are an unexpected increase of water levels is an issue in many places of the world, and it has been known to cause damage to infrastructure as well as human fatalities. The economic effect of this flood event is accentuated for developing nations and countries with a weaker level of economic development. Based on the most recent reports from different parts of the world, terrible floods have resulted in the loss of many lives and have had an impact on a diverse spectrum of people. The last several years have seen significant advancements in technological and computer-based methods to evaluation and collaboration, both of which have contributed to improved detection performance. As a consequence of this, there is an immediate need for a means of recognizing floods. As a result, the Internet of Things devices that have the potential to detect flooding are included into the work that is planned. In order to speed up the process and guarantee precise flood detection, the Decision Making model is combined with the ESP 32 micro-controller.

**Keywords**— Water level depth sensor, ESP 32 micro-controller, Decision Making, Thing Speak Cloud.

## I. INTRODUCTION

Academics are paying a lot of attention to wireless sensor networks as one of the numerous approaches that are being used to keep a watch on floods. This is one of the many methods that are being employed. The ground water, humidity, and radiation are just few of the numerous elements that may be monitored on real - time basis. These large amounts of data may be used to make projections that have the potential to save lives by, for example, reducing the likelihood of a flood taking place. As a result, it is crucial to simplify this process in addition to decreasing the stress on people and getting rid of any costs that are not absolutely required.

Flood disasters have caused incalculable damage to the nation's economy, way of life, and houses as a result of their widespread distribution, frequent occurrence, and numerous, topographical, and possibly fatal qualities. These factors have contributed to the disasters' broad spread. India's tropical climate, lengthy wet seasons, and relative isolation all contribute to the country's high risk of floods, both on their own and as a result of the ecosystem. This risk can be broken down into two categories: floods that are caused by the climate and floods that are caused by the ecosystem. It is impossible to exaggerate how important it is to have a grasp of the floods that are created by rain. Monitoring floods is one of the most difficult, complicated, and essential challenges in engineering. Its primary purpose is to cut down on the number of human and economic deaths.

Recent weeks have seen widespread devastation around the world in the form of disastrous floods, which has resulted in a significant number of lives lost and considerable damage to infrastructure. The prediction of floods has to be carried out rationally in order to allow for the establishment of advanced warning signals, which will serve to warn people of an impending disaster. If there is sufficient warning, it may still be possible to save lives and livelihoods by providing the chance to evacuate or make improvements to the infrastructure. Through the use of intricate computer modeling, it is possible to produce a massive acceleration in the forward march of time. Several modifications are developed with the goal of predicting a broad variety of phenomena, including floods, hurricanes, and other similar occurrences, among other things. It has been shown that computational methods from the area of artificial intelligence, which include neural networks and support vector machine analyzers, are helpful and may be used in a variety of contexts. However, it has become clear that a significant constraint is the inability to confidently offer very exact results owing to values that are beyond the spectral range.

Accurate weather forecasts may be made up to five days in advance. This is the maximum amount of time for which they can be made. Nevertheless, if there is an unexpected change in the world that surrounds us, these facts could be revised. The acquisition of information such as that might be challenging at times. The lack of data presented a significant challenge when it came to attempting to forecast the destruction that would be inflicted by the floods that occurred on the Indian subcontinent. Because to the dams' inability to accurately estimate the runoff velocities, significant damage was done to the infrastructure. This demonstrates the need of having an effective flood forecasting system that takes into consideration several parameters, such as the amount of rainfall, the velocity of streamflow, and the pressure of the water. Floods may often be predicted with the help of these three elements. However, when dealing with a greater amount of data from the real world, the findings indicated a decreased efficacy of the forecast.

## II. LITERATURE REVIEW

D. Samarasinghe [1] established a subsystem to predict massive flooding in Kelaniya, Sri Lanka, by combining the information collected by suspended detectors with the real-life information procured from the Emergency Relief Management Of the organization, the Weather forecasting Bureau, and the Agricultural Division. These three departments are responsible for humanitarian assistance and strategic planning, weather forecasting, and water management, respectively. The unfortunate loss of life and the vast damage of property that are the results of floods are reported in the media on an annual basis. Flooding has been a persistent problem in the Kelaniya area for the last five years, but nobody appears ready to acknowledge that a catastrophe is on the horizon. The Smart Guardian Flood Emergency alert Technology was designed by the authors as a means of protecting individuals from the dangers of floods. If individuals could accurately anticipate what would happen during a flooding, they would take the required precautions to protect themselves along with the most valuable possessions they could take with themselves. The purpose of this research is to measure storm water runoff, user circumstances, and water depth using multiple Internet of Things Devices that have been fitted with monitors and a surveillance system. The user's smartphone will then get a notification when this process is complete. The categorization of the stages was achieved by the use of machine learning techniques.

M. Khalaf [2] research that involve utilization machine learning methods to conduct through machine learning strategies for the diagnosis of flood water severity and frequency may utilize the information acquired via the internet of things framework and devices that have been put on the waterways. The aggregation model used in this study fared well in flood monitoring studies conducted in the past and has the potential to act as a forerunner to flood monitoring tools. When doing an analysis of flood data, this study takes into consideration several categories of water levels, including ordinary, exceptional, and hazardous. The effectiveness of the proposed approach for collective learning algorithms is evaluated using several parameters for measuring performance, such as specificity and sensitivity, in addition to various ways for representation. According to the results, it may be able to provide advance indication of the magnitude of floods by using the appropriate data science approaches and combinations of model-based machine learning.

S. Bande [3] developed a forecasting model to anticipate the occurrence of flood catastrophes by analyzing the data collected from the surrounding ecosystem. A set of sensors collect information and then wirelessly communicate it to a microprocessor so that many aspects of the environment, including climate, moisture, elevation, rainfall patterns, and more, may be monitored. In addition, artificial neural network simulation methodologies are employed in order to develop connections in between information that are fed into the system and the precipitation that is produced as a consequence. Real-time monitoring of the surroundings is possible if the historical values are periodically updated to reflect the most recent measurements and set at frequent basis. Using a Wi-Fi module, low-power endpoints inside the Internet of Things are able to communicate among themselves via the web. An artificial neural network model is used to predict the incidence of flooding and alert inhabitants to an imminent collapse by analyzing the connection between someone precipitation increase and a subsequent increase in water depth in low-lying territories near river discharge regions. This is possible as a result of connection that exists between factors. The information that is gathered from the sensors is uploaded to a repository that is hosted in the cloud. From there, it is transmitted to the users through their smartphones in the form of alerts including such messages or posts on twitter.

In this paper's Section 2, we will be doing a literature assessment on previous work on Parkinson's disease detection models. The section 3 explanation goes into depth about the proposed methodologies. This study comes to a close with a discussion of the implications of the obtained findings in section 4, followed by a conclusion in section 5.

Data integrity, phase prediction, flood simulation, and alert dissemination are the multiple main determinants that make up the core of the forecasting system that was suggested by Sella Nevo [4]. It has a place in both of the aforementioned subsystems. Using nonlinear versus long short term memory networks to simulate stage-based prediction Both the background subtraction paradigm and the multichannel paradigm can be used to calculate hydrological processes; however, the thresholding approach can only measure the width of the submergence, while the multichannel approach can calculate both of the extent and depth of the submergence. The authors propose the multichannel model, which is a replacement to the usual hydrodynamic simulation of flood disaster that takes usage machine learning. This model is being presented for the very first occasion. On the basis of how well it performs when applied to historical information, every model is reliable adequate to be placed into operation. When attempting to predict flood proportions, the long short term memory showed better performance than the nonlinear algorithm in terms of reliability; nevertheless, the background subtraction and multichannel models worked successfully that were on par with one another.

A system that was built on the Internet of Things was given by N. K. Ega Kartika [5] in order to predict the effects of floods. In order to make this flood prediction, the Radial Basis Function was employed. The Citarum River Hall is the source of the details that will be received. A number of different data sets, including totals of rainfall and rainwater withdrawals, are made available by the Citarum River Hall. The findings of the Radial Basis Function Neural Network, which indicate the possibility of flooding, will be included in an upgraded version of a mobile application. Drainage projections may be created with an epoch that is as big as possible, which results in a plausible error value. In addition, the error value is highly restricted, which contributes to an excellent learning rate.

Otoosakiy [6] proposed the use of a prospective machine-learning algorithm that is capable of recognizing prior flood trends and make predictions about the placement as well as the amount of floods. In order to accomplish this, they began by examining the geographical distribution of temperature and precipitation confidence intervals by means of a histogram plot and a kernel parameter approximation plot. They came to the conclusion that, with a couple specific differences, the majority of

rainfall factors possessed distinguishable probabilistic models. Following the fitting and identification of the probability density functions via the utilization of the Fitter component of the programming language, Python the information was normalized in order to eliminate the impacts of spectrum fluctuation on the capability of the techniques to train. The findings showed that Catboost generated the best outcomes after implementing 6 different learning algorithms methodologies all through training and analyzing performance of the models throughout four different requirements. The "elevation" characteristic proved to be the greatest important aspect of the method, as it was the one that generated the best outcomes overall.

W. Dong [7] utilize and design a data mining technique oriented modeling framework in order to layout the hydroelectric dams. This model takes into consideration the difficult urban hydrological environment. Within a supervised learning predictive control modeling framework, a long short-term memory network is used in order to make forecasts about the riverbank as well as the aquatic habitat. It is possible that the particle swarm approach can tackle this linear programming optimization model with a probability limitation, which will make it possible to find the optimal operating schedule for hydraulic units. The suggested method is first implemented and tested in a real urban water conservancy system that employs the use of Smart sensors. This is done so that the accuracy with which the method replicates the hydrodynamic characteristics may be evaluated. The mathematical findings acquired in the process of calculating the most optimal operating schedule for the water conservancy system's water utilities demonstrated that the proposed model was effective.

In the expectation that the technique would run quickly and accurately, Ibrahim [8] attempted to collect up-to-date measurements of the river levels utilizing Arduino ultrasonic detectors. This was done in the expectation that the operation would be successful. In particular, the platform must be compliant with the conventional Graphical User Interface design in order to make it simpler for the consumer to review the data that is provided. Finally, the flood warning notifications must be able to function as envisioned, providing the user with reliable and useful data. The utilization of this knowledge allows individuals to get early notice of impending floods, which provides residents with the opportunity to adequately prepare the houses, assets, and livelihoods for the natural catastrophe. There is reason to be optimistic about the prospect of a swift recovery from either the floods, both emotionally and physically.

W. Khan [9] categorized the data on rivers that were gathered by Internet of Things sensors by employing a data science technique. During the course of this study, the reliability of the support vector machines and the random forest classifiers were investigated using three distinct batteries of experiments. In the first set of experiments, training, testing, as well as validation have all been carried out on a dimensional collection employing principal component analysis. Researchers have conducted experiments to feed classification methods with features that have been selected based on the relevance of the trait, as determined by principal component analysis. In the end, the authors conducted tests in which they employed both the real dataset, which had an imbalanced presentation of the classes, as well as a balanced dataset that was created using artificial minority frame interpolation. In accordance with the results, the standard of erroneous outcomes utilizing unequal data was continuously underperformed by the balanced depiction of specimens when tested compared them. The random forest were capable of achieving a high degree of precision when the values of important attributes were used in cross-validation processes. This illustrates that machine learning related data science approaches, in combination with Principal Component Analysis-based feature importance assessment and extraction of features, have the potential to be used as an effective instrument for the forecasting and classification of flood risk categories.

The idea that was made by J. A. Parra Plazas [10] is aimed toward the usage of data that is dependent on an IoT network in order to feed knowledge to the estimation method that employs computational intelligence methods in order to conduct effective flood forecasting. The material used in this project proposal comes from a number of different meteorological and hydrological stations that are connected to mobile telephone networks. The process of conditioning the model using data variables like as level, rainfall, and weather, amongst others, is analogous to the building of the computational intelligence model. The foundation of the first model of cognitive computing, which would later be developed based on in the experimentation that is being presented, will be made up of three different elements.

S. Miao [11] proposed using a combination of the Convolutional Gated Recurrent Unit model and indeed the multivariate Gaussian distribution technique in order to anticipate and identify irregularities in the quantities of rainwater. The Gated Recurrent Unit model were employed in a bid to understand the long-term includes sustainable included within a time series. On the other hand, a Convolutional Neural Network were implemented in order to acquire the features contained within the time series analysis. The data collected from the water level sensors together with the results of a strategy that included convolutional neural networks with generalized ridge regression have been utilized to make projections about the quantities of the water. In the end, a multivariate Gaussian distribution modeling was used to assess the probability of atypical water level behaviorism focuses on the resultant posterior probability. This evaluation was done using the model. The outcomes of the tests demonstrated that the Convolutional Gated Recurrent Unit model significantly improved when contrasted to other approaches that are considered to be state-of-the-art nowadays. The authors made use of the Convolutional Gated Recurrent Unit framework in conjunction with publicly available data in order to detect anomalies or deviations in a response variable. Using data obtained through river water level monitors, it was possible to demonstrate the methodology's usefulness.

The alternative that was recommended by Jayashree S. [12] does not require the use of the internet, it consumes less power, it notifies individuals in a straightforward fashion, it does away with the necessity of performing complex computations, and it does away with the requirement that mobile towers televised communications. After experiencing a catastrophic loss not so long ago, Chennai had an extreme and immediate need for this repair to be completed. The monitoring systems and stream sensor that are used to detect and document water elevation and speed are shown in the conceptual methodology as being part of the intended network infrastructure for the DAM rain facility. The microcontroller would synchronize the server regardless according to whether the level of water is minimal, moderate, or excessive compared to the criterion. The server is continually modified with the most recent water level available. If the quantity climbs further than the minimum, ZigBe will start sending

out warning signals to the appropriate recipients. In order to determine the rate at which the water is moving, flow monitors are also used. The system will get an alert as soon as possible if even the smallest tiny change in the trends of flow. Each and every one of these measurements is sent to the server via the ZigBee transmitter.

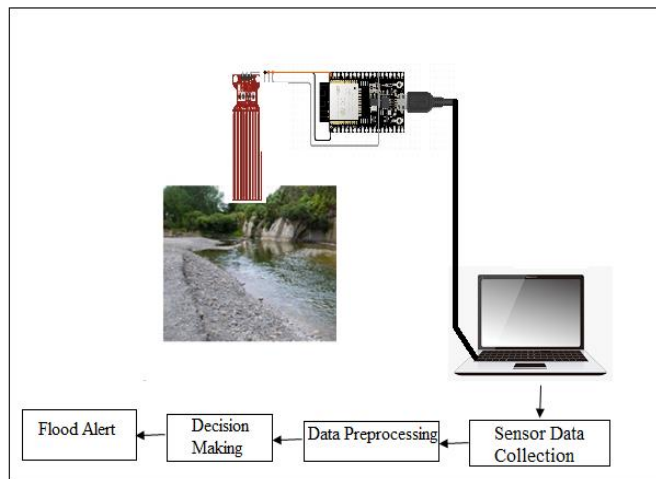


Figure 1: System overview

The system overview shown in Figure 1 above serves as a representation of the technique that has been proposed to implement an IOT early flood monitoring system. The implementation of a number of the steps that are explained below contributed to the proposed approach.

*Step 1: Sensor Data Collection:* The process starts by calibrating and attaching the order on a board to the water level sensor. However, the board has been connected to the laptop for this purpose, and the API is built into the microcontroller board. The ESP32 board connects to the sensor to provide power and accumulate input values. The sensor has an input for power and an output for data that is transferred to the board. The board is connected by putting a Python programme onto it with the intention of gathering sensor data. The board receives a Python code, which is subsequently uploaded, and the board immediately begins to gather sensor data. These values are recognized as input and effectively stored in a list that the Python code may access.

The Specifications of the ESP 32 model can be seen below in the figure 2

Module model	ESP-WROOM-32s
SPI Flash	32Mbit(default)
Support interface	UART/GPIO/ADC/DAC/SDIO/SD card /PWM/I2C/I2S
Integrated crystal oscillator	40MHz Crystal oscillator
IO Port	38
Antenna	Onboard antenna
Power Supply	Voltage 3.0V ~ 3.6V, Typical 3.3V, Current >500mA
Operating Temperature	-40 °C ~ 85 °C
Storage Environment	-40 °C ~ 120 °C
Length(mm)	25.4
Width(mm)	48.26
Height(mm)	3
Weight(g)	10
Shipment Weight	0.015 kg
Shipment Dimensions	12 × 8 × 2 cm

Figure 2: Specification of the ESP 32 model

The connectivity circuit diagram of the ESP 32 with the water level sensor can be seen in the below mentioned circuit diagram in figure 3.



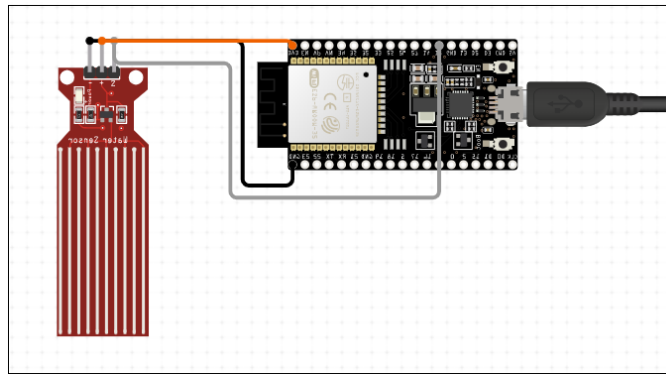


Figure 3: Circuit Diagram of the proposed model

*Step 2: Preprocessing:* Once the sensor input values have been processed and propagated as a list, these are provided as an input to the Python code. These variables effectively interface and look for a water level threshold value. The junk values have been eliminated from the preprocessed data, the strings are reduced, and the outcomes are utilized by the subsequent step in the method to identify a flood level event.

*Step 3: Decision Making:* The sensor has been set up so that it can be put on a river's flood plain or another particular region where the flood level is being tracked. The sensor's results alter or rise above a preset cutoff value if the water reaches a particular level. Once this limit is crossed, it is clear that the water level is growing uncontrollably above the desired level, and the circumstance can be classified as a flood level scenario. The if-then rules of this decision-making module are employed to determine the scenario. A voice alarm is sounded for purposes of evacuation and other disaster management measures as soon as a flood level scenario is achieved and detected by the decision-making approach. An alert is also immediately generated for the adjacent station to avoid life and death.

#### IV RESULTS AND DISCUSSIONS

The mini-python IDE and some libraries written in the Python programming language were used to build the proposed framework for an efficient flood warning system. This made it feasible for the automatically generated flood warning to be successful in saving lives in a real-time scenario. The technique suggested was implemented on a developer laptop running Windows loaded with an Intel Core i5 CPU and 8 GB of RAM. To measure the dependability of the provided solution, the errors encountered when deploying and executing it must be assessed.

##### Performance Evaluation through Root Mean Square Error (RMSE)

By subtracting the error between the obtained and expected evaluations, the root mean square error (RMSE) is determined. As a consequence, it is feasible to implement an efficient policy that can accurately determine the method's efficacy. Through the application of equation 1 below, the appropriate evaluation of the flood warning is examined and its RMSE is calculated.

$$RMSE = \sqrt{(x_p - x_o)^2} \text{ ----- (1)}$$

Where

$X_p$  – Expected number of Flood warnings

$X_o$  – Obtained number of Flood warnings

An increasing number of flood warnings that have been processed by the suggested system were employed in the experimental evaluation. This enables a study of exactly how the technique works in order to facilitate the efficient evaluation of the responses. With each iteration of the methodology, more flood warnings are reviewed. The amount of variation between the system's actual number of flood warnings and the predicted number of flood warnings is shown by the root mean square error.

The fact that a sizable portion of the input flood warnings were accurately analyzed using the methodology may be responsible for the astounding RMSE that was acquired by applying the strategy. The outcomes of the exploratory research have been summarized in Table 1 below, and the pertinent metrics have been plotted on the graph that can be found in Figure 4 below.

Experiment No	Expected No of Flood Warnings	Obtained No of Flood Warnings	MSE
1	3	3	0
2	6	6	0
3	10	9	1
4	13	12	1
5	18	16	2

Table 1: Mean Square Error( MSE) Tabulation

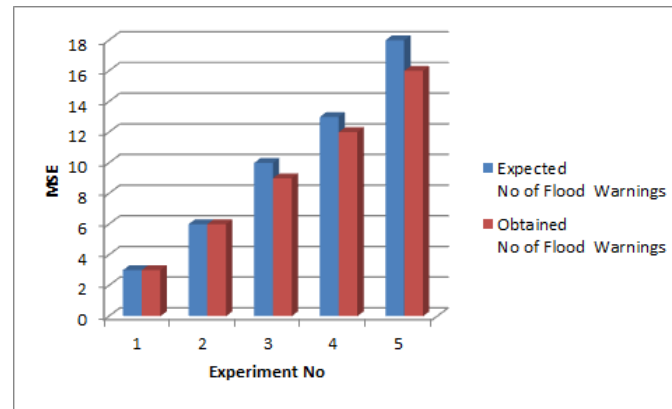


Figure 4: MSE comparisons

These findings from the initial application of this early flood warning system show that the suggested methodology is workable. We calculated the root-mean-squared error to figure out the severity of the methodology's errors, and we discovered that the proposed approach had an RMSE of 0.8944. This outstanding outcome demonstrates that the answer sheet evaluation process was successfully implemented.

## V CONCLUSION AND FUTURE SCOPE

The proposed methodology for the flood detection and alert generation has been elaborated in detail in this research paper. In many parts of the globe, flooding caused by an unanticipated rise in water levels is a problem. Flooding has been known to inflict damage to structures as well as human deaths. The economic impact of this flood event is magnified for nations still in the process of growing their economies as well as for those that have reached a lower degree of economic development. According to the most recent reports coming in from various regions of the globe, devastating floods have caused the destruction of a great number of lives and have had an effect on a wide variety of individuals. There is a requirement of an effective approach that can considerably improve the flood detection and achieve the alert to save large scale losses of property and life. The presented approach initiates with the water level sensors being deployed across the river bed and the flood plains. These sensors are in turn connected to the microcontroller the collects the values and transmits it to the system. The sensor data collected is preprocessed to remove any unneeded values from the collected data. The reprocessed data is then utilized for the purpose of Decision Making that leads to the flood alert. The approach has been evaluated for its effectiveness which has resulted in highly useful outcomes.

For the future enhancement this model can be enhanced deploy in real time flood monitoring across a city to avoid losses.

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