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Road Flood Warning Detection Using Wireless Sensors and Fuzzy Logic to Support Gresik Smart City

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***Abstract* — In this paper, we study how to overcome the urgency of flooding that occurs suddenly around the city of Gresik using wireless sensors with fuzzy logic to support Gresik smart city. The process of making flood alarm detection is very difficult to solve. To overcome this, we propose the use of wireless sensors using fuzzy logic in flood-prone areas. Fuzzy logic is used to process sensor data to find more accurate results to improve accuracy and efficiency. Two sensors are installed at the flood warning test point, using Wemos D1 MINI / NodeMCU so that the IoT network can be connected to the server. The data obtained from the measurement results are processed using fuzzy logic. Fuzzy will provide flood warnings automatically when the height is 30 cm and above. The method used is qualitative and product development research. The results after conducting 100 trials showed that there were six cases of errors in reading the water level, so that from the trial an error of 6% was obtained from the sensor made and a success accuracy of 94% was obtained. The research conducted concluded that the research results were as expected. In this way, public safety against sudden flood events will increase.**

***Index Terms* — Flooding; Internet of think (IoT); Fuzzy; Server; NodeMCU**

I. INTRODUCTION

This research was carried out to overcome flooding in Gresik so as to support Gresik Smart City which is expected by the city government because of the lack of speed of community response to the increasing flood points that occur on the roads around Gresik city at certain times or when floods are illegible, it is hoped that this research can be useful to support the Gresik city government program as a disaster response area. IoT is very useful for providing early and updated warnings in real time, Real-time data is critical in Internet of Things (IoT) applications as it enables rapid response and decision-making based on current conditions. In the context of IoT, real-time data refers to information that is collected and processed almost instantly after an event occurs, allowing devices and systems to communicate and react immediately. The use of fuzzy method is used because it has advantages over other methods because the fuzzy method is very well known for decision-making.

In the last decade, there has been a great deal of scientific activity exploring how camera images and wireless sensor data from Internet of Things (IoT) networks can improve flood management. This paper presents a systematic review of the literature on IoT-based sensors and computer vision applications in flood monitoring and mapping. The paper contributes by highlighting the main computer vision techniques and IoT sensor approaches used in the literature for real-time flood monitoring, flood modeling, mapping, and early warning systems, including water level estimation. [1] However, research conducted by Preethi Rajan [2] With the advent of the Internet of Things (IoT), businesses have gained access to vast amounts of data generated by interconnected devices. Leveraging IoT analytics and marketing intelligence, organizations can extract valuable insights from this data to enhance decision-making processes. The difference between this study and other studies is the design of this IoT-based flood early warning application will help Gresik residents by providing voice signals and notifications in the application for remote flood monitoring. The

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difference with other studies is the notification notification in the system.

Flooding occurs when river water overflows into the surrounding area because the river is unable to hold rainwater due to siltation. In addition to rainfall, factors such as soil and human characteristics play a role in causing flooding. Causes of flooding include rainfall, watershed characteristics, river flow capacity, land use changes, and river management ranging from regional planning to regulation. [3] however research from Wicaksono [4] Flooding occurs when rainfall is low and rivers can hold water well because there is no siltation. Factors such as soil type and human activity do not influence causing flooding. Flooding is temporary water that is common in many places in Indonesia, including Lamongan Regency. In this area, in early 2022, seasonal flooding caused many residents' houses, agricultural land, and access roads to be submerged in water. This is due to its topography, which is characterized by lowlands and waterways. [5]

Researchers have previously researched flood hazard early warning systems. Research by Indah Fitri Astuti includes the use of Arduino Uno ATMega328 microcontroller, ultrasonic sensor to detect distance, LCD to display distance information, buzzer as alarm status notification, and GSM module SIM800L as SMS gateway system. Research by Indri Handayani also includes the use of Arduino Uno microcontroller, HC-SR04 ultrasonic sensor, LCD with I2C module, buzzer, and GSM module SIM900. In this study, an early warning flood detection system was built using Arduino Uno as a microcontroller that controls ultrasonic sensors to detect distance, LCD to display distance information, a buzzer as an alarm status notification, and a GSM module SIM800L or SIM900 as an SMS gateway system to provide information to users via SMS. [6]

Jonshon Tarigan and Achmad Muzakky used NodeMCU ESP8266, water level sensors, buzzers, and the Blynk application to detect and provide flood status notifications. This approach also aims to provide early warning to the public. This technology shows developments in utilizing microcontrollers and sensors for disaster mitigation purposes. however [7] The black box test results show the performance of Sensor application software can all function properly. While the results of the compatibility test show the application can run on various android systems.

My research is supported by several other studies, including researcher Jonshon Tarigan, who designed an early flood detection system using Arduino Uno, LCD, and potentiometer sensors to determine whether water levels have reached flood levels. In addition, Achmad Muzakky also conducted research using the NodeMCU module ESP8266 as a wireless data processor, water level sensor, buzzer, and Blynk application to display status notifications on Android devices [8]. This research is also supported by [9] These two studies aim to detect floods early and provide warnings to the community regarding the status of water levels to reduce the risk of flood disasters.The test results of this method have an accuracy value of 65%. With the ANFIS (Adaptive Neuro Fuzzy Inference System) method, you can predict changes as a way to make decisions regarding handling information. Apart from that, the system will be more organized and efficient if it uses fuzzy [10] other research from [11] This research paper presents a comprehensive study of anomaly detection techniques specifically designed for IoT sensors. We examine the different types of anomalies that can occur in IoT sensor data, including sudden changes, outliers, and malicious attacks. We also explore the unique characteristics and requirements of IoT sensor networks, such as resource constraints, heterogeneous data, and dynamic network topologies.

The result of this study is the construction of a flood detection system based on Arduino Uno that can improve who and the status of flood hazard according to changes in water level [6].

Previous research by Indah Fitri Astuti and Indri Handayani has used the Arduino Uno microcontroller and various sensors (such as ultrasonic sensors) to build a flood early warning system. They integrate LCD, buzzer and GSM module as the main components to detect and provide notifications regarding flood status. The application of this technology is an important basis for further development in early flood detection.

The development of technology to monitor environmental conditions and disasters has included a variety of sensors, such as flood detection devices that use Doppler Radar. The development of technology to monitor environmental conditions and disasters has included a wide variety of sensors, such as flood detection devices that use Doppler Radar. which explains that Some properties of ultrasonic Doppler sensing from other sensing techniques-high frame rate, low computational overhead, real time data analysis readout, and distance. the disadvantage of this system is, as it is not vision based. [12]. However, this method still involves complex hardware design and requires significant costs. [13] The proposed technique is robust to clutter interference and water ripple fluctuations by selecting an appropriate carrier frequency. Experiments are conducted to monitor the water level in a rain barrel as the water flows out. Both simulations and experiments show that the proposed technique can accurately monitor the water level with high accuracy in the millimeter scale.

In addition, there are other flood detection systems that use microcontroller-based ultrasonic sensors, but the response is still slow, about 5.4 seconds, and relies on SMS gateway media. To overcome these obstacles, further research leads to the Internet of Things (IoT) approach, where this technology uses the Internet network as a link. IoT is basically a remote control or monitoring technology that uses the Internet, often using Android gadgets or devices as monitoring media, making it easier for users to operate. Gresik is a flood-free city, so in urban planning, sensors are needed to respond in case of flooding. [14].

In recent research, IoT approaches have been proposed as a solution to improve the responsiveness and efficiency of flood detection systems. IoT uses the Internet network to connect sensors, allowing users to monitor flood conditions in real time through Android devices or other devices. Gresik, as an example of a flood-free city, requires this approach as part of urban planning to anticipate potential flooding.

However, there are gaps in several of the studies above, including:

1. Technological Complexity and Cost [15]: Although many technologies and methods are used in research for flood detection, such as the use of microcontrollers, sensors, LCDs, buzzers, and communication modules (such as GSM or IoT), some methods such as the use of Doppler Radar are proven to have a level of complexity high and expensive. This is a gap because the continued implementation of this technology in areas that require economical flood detection solutions may not be possible.

2. Response Speed and Efficiency [15]: Several studies used microcontroller-based ultrasonic sensors with a slow response, namely around 5.4 seconds. This indicates a gap in the speed of system response, which can be critical in emergency situations such as floods. New technologies such as IoT are proposed to overcome these obstacles by utilizing faster internet connectivity.

3. Adjustment to Local Context [15]: The research states that Gresik is a flood-free city, but urban planning is still needed that involves sensors to respond to potential flooding. This highlights the need for adaptation of flood detection technology to take into account the specific characteristics and needs of each location or region.

By paying attention to these gaps, it is hoped that the development of early flood detection technology can focus on solutions that are more affordable, faster, and better adapted to the needs of local communities. The integration of IoT and other technologies is key to increasing the effectiveness and efficiency of flood detection systems in the future.

The objective of this research is to develop an efficient road flood warning detection system using wireless sensors and fuzzy logic algorithms. This aims to improve the preparedness and response capabilities of Gresik Smart City to reduce the impact of flooding on road infrastructure and public safety. Another objective of this research is to assess the feasibility and effectiveness of using wireless sensor networks for rapid detection of road flooding in the context of Gresik Smart City. This includes evaluating the reliability, accuracy and real-time capability of the proposed system under different environmental conditions and flooding scenarios. In addition, this research also aims to contribute to the advancement of smart city initiatives in Gresik by integrating innovative technologies such as wireless sensors and fuzzy logic into flood management strategies. The results of this research are expected to provide valuable insights for policy makers and urban planners to develop sustainable and resilient infrastructure to address the challenges posed by flood events.

II. RESEARCH METHOD

Research Diagram Road Flood Warning Detection Using Wireless Sensors and Fuzzy Logic to Support Gresik Smart City, the system uses ultrasonic sensors based on HC-SR04 microcontroller, D1 mini/Nodemcu, database server, and desktop display application in Figure 1.

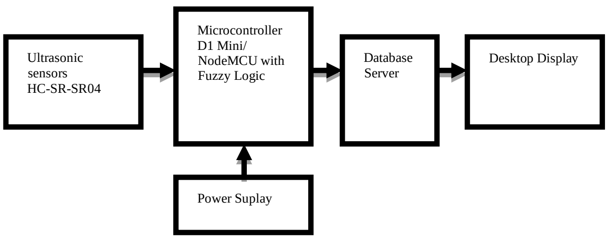

Figure 1.Research Diagram System [16]

Research method [16] is an activity performed to gather data or information related to similar research to design a system. In system design, research methods are needed so that the research process can run well and achieve the expected goals. Different types of research methods can be used, such as quantitative research methods [17], qualitative research methods, and combined research methods. In figure 2,

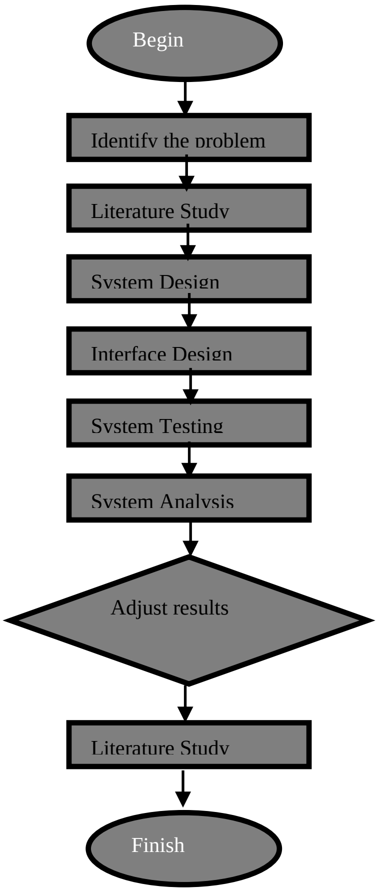

Figure 2. Research Method Flowchart [16]

Systematic steps can be seen in the research method which includes identifying problems, formulating problems, reviewing the literature, forming hypotheses, determining research variables, establishing work procedures, collecting data, processing data, drawing conclusions, and reporting results. References from various sources such as books, journals, articles, and the Internet are also needed to determine the appropriate components based on the analysis.

1. Problem identification [16] is an activity that analyzes flood problems, which often occur in several areas, causing people to suffer material and human losses. In addition, they do not know when the flood will occur. Problem identification is a very important first step in a study because research problems can

determine the quality of research and whether an activity can be called research.

2. Literature studies [16] are conducted to obtain information about materials such as ultrasonic sensors, microcontrollers, and other modules by studying various references from previous research journals that are by the research material. This step aims to understand the usefulness and characteristics of devices to be used in early flood detection systems, as well as to produce more efficient systems, reduce errors, and improve the results of this research.

3. At the system design stage [16] , the operating steps present in the system will be described using a flowchart. Here is a flowchart drawing of the designed system, which includes the process of connecting to the internet, distance reading, sending distance data to a server, data storage to a database, state state reading, and the process of displaying data to the user interface. This flowchart image provides a visual representation of the process flow and the steps that the system will follow in dealing with flood early warning issues.

2.1 Internet Of Things (IoT)

The logical advancement of the Web of Things is very encouraging in the modern era 4.0 to improve lives with the existence of ingenious controls, board systems and robotization with real gadgets that work together and connect through web networks. The Internet of Things, or IoT, has received a lot of attention lately since it has drastically altered human existence. In a wide range of applications, including smart buildings, smart health, smart transportation, and more, the Internet of Things facilitates the sharing of information or data [18]. IoT research on intelligent service systems is currently trending. IoT generates various kinds of data from sensors or smartphones. The data generated from IoT can become more useful and actionable if data analysis is performed [19] .We evaluate our proposed approach using a real IoT dataset, and show that it reduces the detection delay by 84% while maintaining almost the same accuracy compared to moving the flood detection task to the cloud [20]. Moreover, our evaluation also shows that the performance of this scheme is better than other baseline schemes. [21] The internet of things will also facilitate human activities in daily life; For example, we can use a computer or cellphone to check the room temperature. Human collaboration is decreasing due to future data exchange capabilities between PCs and electronic gadgets, it is increasing with web offices and other administrations due to client demands. The IoT model design is shown in Figure 3. [22]

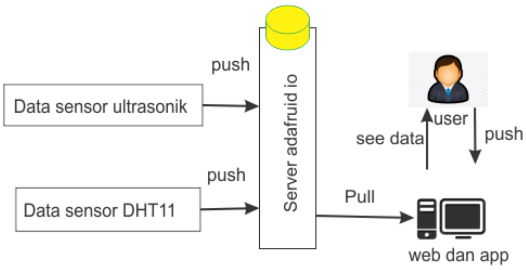

Figure 3. IoT Architecture Model

The IoT data flow process is shown in Figure 1. Using the MQTT [23] (Message Queuing Telemetry Transport) protocol, ultrasonic water level sensor data, and DHT11 air temperature and humidity sensor data for weather conditions are transmitted to the Adafruid Cloud Computing IO. MQTT is a subscribed communication protocol that is lightweight, easy to understand, and intended for devices with limited capabilities. MQTT can support IoT devices. MQTT at a basic level has a data trading center between supporters and distributors, specifically MQTT representatives. The distributor is the sender of information, e.g. sensors, while the endorser is the receiver of information, e.g. people. The schematic of the DHT11 sensor circuit connected to the Wemos D1 The small scale and pins used on the Wemos D1 Mini/ / NodeMCU to be connected to the DHT11 sensor, which has been set as a temperature and humidity gauge to determine weather patterns, are shown in Figure 4 [24]

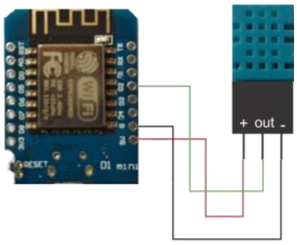

Figure 4 DHT11 sensor circuit with Wemos D1 MINI/ NodeMCU

Then, plan the Ultrasonic sensor circuit associated with Wemos D1 Reduced and the pin used on Wemos D1 Mini than normal so that it is associated with the Ultrasonic sensor and adjusted to measure the water level in the water retention lake, shown in Figure 5.

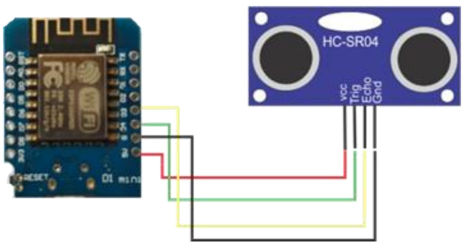

Figure 5 Ultrasonic sensor circuit with Wemos D1 MINI/ NodeMCU

Figure 6 illustrates the circuit that regulates the number and speed of the pump, the L298 controller connected to the Wemos D1 MINI, and the pins used to connect the L298 pump control sensor to the Wemos D1 MINI to regulate the number and speed of the pump. Water pumps according to the water level in the infiltration pond and the weather.

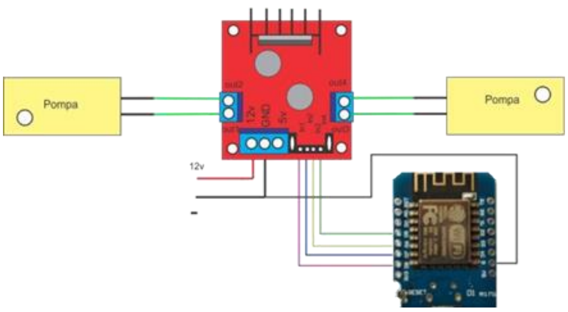

Figure 6 L298 pump controller circuit with Wemos D1 MINI/ NodeMCU

2.2 Fuzzy Tsukamoto's logic

Fuzzy knowledge-based systems exploit the tolerance for imprecision, partial truth, and approximation to achieve a close resemblance to human activity and reasoning intuition [25]. Subtle reasoning is a part of software engineering that focuses on truth judgment, which has many properties and very complicated frameworks to deal with. Instead of judging truth, traditional logic is meant to control a single outcome with unrelated values of 0 (false) or 1 (valid). Fluffy Reasoning has a true truth value in the range of 0 to 1. The direction starts from reducing the number of very large qualities to the value of the enrollment degree, which starts from dealing with a very large range of variable qualities within a subtle framework [26].

In subtle logic, there is the ability of participation to determine the value of the participation rate of a variable. The registration ability used is a three-sided curve that shows the scheduling of each information input point into a membership degree value that has a period of up to 1. One way that can be used to obtain the participation value is to use a certain ability and value approach. standard [27]. Fuzzy rule interpolation forms an important approach for performing inference with systems comprising sparse rule bases. Even when a given observation has no overlap with the antecedent values of any existing rules, fuzzy rule interpolation may still derive a useful conclusion [28].

The technique used in this exploration is Tsukamoto Fluffy. ANFIS is an adaptive network based on a fuzzy inference system. The fuzzy assessment model using the Adaptive Neuro-Fuzzy Inference System (ANFIS) produces better and more accurate assessments[29]. The factors used are the level of air stickiness obtained from the DHT11 sensor and the distance of water obtained

from the ultrasonic sensor. For results, the range of values is 0-100. The course of this strategy is shown in Figure 7.

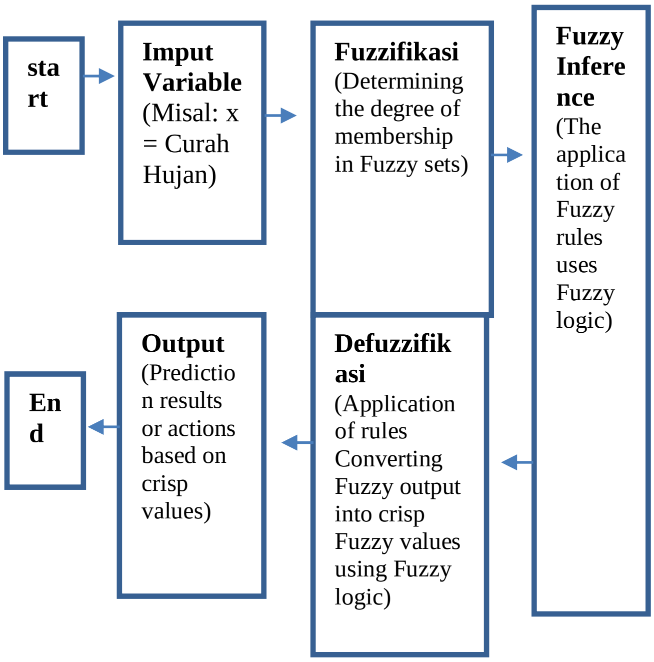

Figure 7 Fuzzy Tsukamoto Stages

Important Section Markers:

a. Fuzzification:

This section shows the process of determining the degree of membership of input variables in a fuzzy set. This is a key step in the Fuzzy Tsukamoto process where the input variables are expressed as membership functions on a fuzzy domain [30].

b. Fuzzy Inference:

This section represents the application of fuzzy rules using fuzzy logic to the degree of membership of input variables. These rules are applied to produce fuzzy output [10].

c. Defuzzification:

This stage converts the fuzzy output from inference into crisp values or firm values that can be understood and used to make decisions or further actions [10], [29]

Each step in this flowchart reflects an important stage in the Fuzzy Tsukamoto process [31], which includes representing input values in a fuzzy domain, making fuzzy decisions based on established rules, and converting fuzzy decision results into concrete values to produce the final output.

The main stage is fuzzification, a cycle in which input factors are transformed into new qualities, which then become semantic factors by using registration capabilities. Then we enter the phase of forming a fuzzy information base (a rule base such as IF... THEN). After that, this data is sent to the knowledge base with n fuzzy rules IF-THEN. Tsukamoto's fuzzy model generally follows the form IF X and Y THEN A, where X and Y are fuzzy sets. If the number of rules is large, a relatively large conglomeration of rules will be completed. The third is motor deduction, which is an interaction that uses the suggestive ability of MIN to obtain a predicate α an incentive for each standard (α1, α2, α3,... αn). Then, each α predicate value is used to compute the conjecture results explicitly (freshly) for each standard (z1, z2, z3,... zn). The final stage is defuzzification using the mean. The frame results are obtained as crip values from the accumulated results obtained during defuzzification. [32]

III. RESULTS AND DISCUSSION

A. Ultrasonic Sensor Specifications

In tests conducted to detect water levels using ultrasonic sensors of type HC-SR04, it was found that the accuracy of the HC-SR04 sensor when used in the designed system had an accuracy level of 0. The ultrasonic sensor HC-SR04 is also used in other studies to detect water levels as a flood detector. The sensor is like table 1.

Table 1 Ultrasonic sensor specifications

Information	*Result*
Operating source voltage	5.0 V
Current consumption	15 mA
Operating frequency	40 KHz
Minimum distance	2 cm
Mximum distance	4 cm
Gauge wave bounce angle	15 degrees
Tool dimensions	45 x 20 x 15 mm

In the figure, you can see an ultrasonic sensor type HC-SR04, which can read a minimum distance of 2 cm and a maximum distance of 4 cm. The bounce angle of the measuring wave is 15 degrees, by working the trigger pin emits ultrasonic waves, and then the echo pin receives the results of the reflection of the waves hitting the object. The HC-SR04 ultrasonic sensor is also used in other studies to detect water levels as a flood detector.

3.1 Testing Connecting Nodemcu to the Internet

To test the internet connection, it can be done using several internet networks and ping commands on Command Prompt (CMD) or terminal. This test is carried out to determine how long it takes to connect to the internet and ensure a stable internet connection in order to apply Internet of Things (IoT) technology properly.

Table 2 Internet Testing Results

No	SSID	Provider	Speed (Mbps)	Connection Length (seconds)
1	Digisoul	three	2	10
2	Surba	MNCC	10	4
3	RW 5 Ciganjur	MNCC	10	3
4	Lonah Plus	MNCC	6	5
5	Buat_TA	Indosat	1,8	12
Average connection time				6,8

The test results of the NodeMCU connection to the internet, recorded in Table 2, show variations in connection duration. Connection time is measured by counting points on a preset serial monitor with a delay of 0.5 seconds. Based on experiments, the average connection time was 6.8 seconds. In addition, when the connection process is successful, a display will appear as shown in Figure 7.

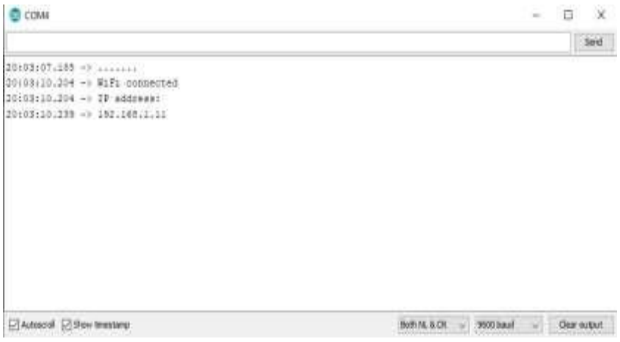

Figure 2 Process of Connecting to Wifi

b. Water surface distance testing with ultrasonic sensor

Tests are performed to evaluate the accuracy of the ultrasonic sensor in reading distance. The trial was carried out using a container filled with water with a height of 30 cm, and an ultrasonic sensor was placed on top of the container at a safe distance of 4 cm from the surface of the water. These test results are important to determine the accuracy and reliability of ultrasonic sensors in a wide range of applications, including water level monitoring systems for early detection of floods.

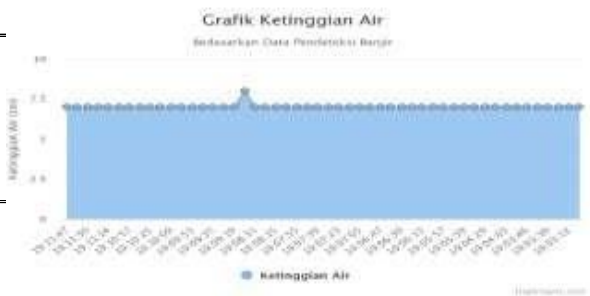

Figure 3 First 50 Data Test Results

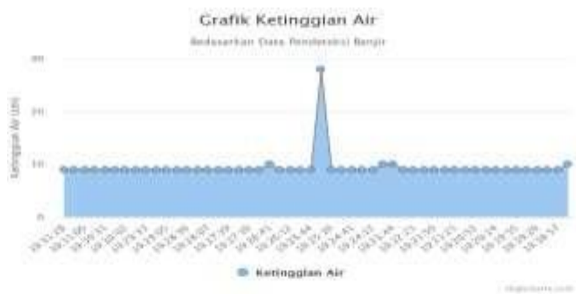

Figure 4 Second 50 Data test results

The graph above illustrates the results of 100 experiments with two trials at different water levels, showing six distance reading errors. From the first 50 data with a water height of 7 cm, there is one error at the 33rd input with an error value of 1 cm. Meanwhile, in the next 50 data with a water height of 9 cm, there were five errors. The first error occurs at the first input with an error value of 1 cm, the second and third errors appear at the 18th and 19th inputs with an error value of 1 cm, the fourth error occurs at the 25th input with an error value of 19 cm, and the fifth error occurs at the 30th input with an error value of 1 cm.

C. Database Testing System Result

In database testing using the existing graph display in phpMyAdmin, the total number of data entered reached 409 data.

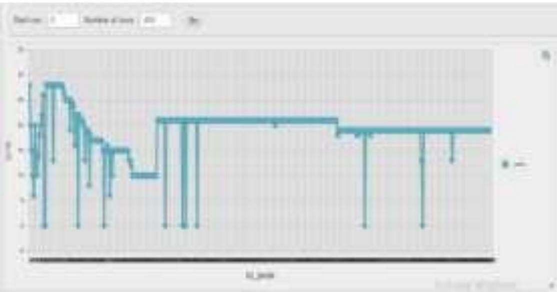

Figure 5 Graph database

The graphic illustration above indicates the amount of data present in the database. Based on the information presented, there were a total of 409 data, and the process of inputting data into the database went without any errors.

Figure 6 Display time data

In the illustration, it can be seen that the time taken by the database to display 409 data is 0.0020 seconds. These experiments were carried out to ensure the suitability of data storage received from ultrasonic sensors with existing systems. Data that has been successfully stored in the database will be displayed in real-time on the website page. The average time required to transfer data from the sensor to the database is 5 seconds, measured with the help of a stopwatch. The results of this research make the GRESIK district government very happy, he supports the research and manufacture of this flood-based detection tool (IoT).

Errors in sensor readings in flood-prone area warning detection systems using wireless sensors and fuzzy logic can occur due to various factors, such as environmental disturbances, improper sensor calibration, hardware degradation, signal interference, and errors in data processing. For example, sensors installed in the field can be subject to interference from extreme weather conditions, dirt buildup, or physical damage resulting in inaccurate data readings. In addition, signal interference from other electronic devices or wireless network issues can also interfere with data transmission from the sensors to the central system. Reducing these errors in future iterations is crucial to improving the reliability and accuracy of the flood detection system. Some steps that can be taken include improving sensor quality and calibration, implementing more sophisticated data processing algorithms to identify and correct inconsistent data, and using redundancy techniques by placing multiple sensors in one location to validate data. In addition, the development of regular monitoring and maintenance systems for sensors can help detect problems early before they have a significant impact on system performance. By addressing the sources of error and increasing the system's resilience to disturbances, the findings from the implementation of this technology will be more accurate and reliable. This not only improves early detection and response capabilities to potential flooding, but also supports Gresik Smart City initiatives by providing timely and relevant data for data-driven decision-making, thereby improving the safety and quality of life of the community.

The findings of this research are 1. Accurate Flood Detection System: This research found that a flood detection system using wireless sensors and fuzzy logic was able to provide accurate detection of flood events on flood-prone roads in Gresik. The accuracy of this system is a significant contribution to improving flood awareness and response in the region. 2. Fast Response Time: The results show that the system has a fast response time in detecting flood events and providing timely alerts to the community. This rapid response helps in taking effective preventive and responsive measures to mitigate the impact of flooding. 3. System Reliability: This research also found that the flood detection system using wireless sensors and fuzzy logic has a high level of reliability. During the testing phase, the system demonstrated consistent performance in monitoring water levels and providing notifications, with few incidents of false alerts. This reliability is an important cornerstone in ensuring the system's effectiveness in reducing flood risk in Gresik Smart City.

The results of this research are in line with or supported by Preethi Rajan [2] highlights the significance of IoT analytics in leveraging data from interconnected devices for informed decision-making. Unlike previous studies, this research focuses on designing an IoT-based flood early warning application tailored to Gresik residents. Notably, it incorporates voice signals and notifications within the application for remote flood monitoring, distinguishing it from other studies. This wireless sensor-based system offers several significant advantages. In terms of cost, wireless sensor systems are relatively more affordable. In terms of efficiency, wireless sensor systems are able to transmit data in real-time, allowing early detection and rapid response to potential flooding. In terms of accuracy, although wireless sensors can be affected by environmental disturbances, Other research that support my research by alabi [33] Simulation was carried out for the F-DCRP, LEACH and Crisp Data controlled routing protocol (DCRP). The performance of the three protocols were obtained and compared. The result showed that Cluster head (CH) load was better shared uniformly among all the nodes. Percentage of packets dropped showed that the proposed F-DCRP was 10% lower compared to DCRP and 50% lower compared to LEACH resulting in more packets sent per round and greater reliability compared to LEACH and DCRP. The network lifetime was also improved by 40 % when compared to LEACH and DCRP. This F-DCRP, LEACH and Crisp Data (DCRP) sensor-based system offers several advantages. In terms of cost, the wireless sensor system is relatively more expensive, In terms of efficiency, the F-DCRP, LEACH sensor system is more efficient in terms of transmitting data, In terms of accuracy, although the F-DCRP, LEACH sensor is more robust against changing weather attacks. Other research from pooja [34] This paper presents a method of alert flood detection. This paper focuses on the development of the system which will determine the current level of water by employing sensors and by using a wireless sensor network that will provide notification viaESP32 Wi-Fi module. The system also sends a notification of an alert through the IoT mechanism to all stakeholders. As the parameters of a flood are uncertain hence fuzzy logic is used to develop a flood detection system. Fuzzy logic produces results that resemble human results. Overall, the use of wireless sensors and fuzzy logic in flood warning detection not only offers a more cost-effective and efficient solution, but also provides a fairly high level of accuracy under varying and uncertain conditions, supporting the Gresik Smart City initiative in improving the safety and quality of life of its residents.

IV. CONCLUSION

The research and test results show that a fast and stable Internet connection is required for the NodeMCU to connect to the server. Out of one hundred water surface distance test data using ultrasonic sensors, there were six errors in distance readings, with five errors of 1 cm and one error of 19 cm, with a success rate of 94%. The system is able to store and display data directly on the website, with an average data transfer time from the sensor to the database of about 5 seconds. IoT technology has the potential as a water level monitoring tool to detect potential flooding, present information online, and provide notifications in dangerous situations so that local residents can be aware of it. In the application of multi-sensors with fuzzy methods based on IoT for flood early warning, the information is communicated with a buzzer through the dashboard LCD screen. The application of sensors on Arduino and the testing of sensor pins around roads that are usually flooded have been successfully carried out. With this sensor tool, the development of a flood-free city of Gresik will be greatly helped.

Future research will focus on developing IoT-based multisensor applications with fuzzy methods for flood early warning using mobile apps, including optimizing the accuracy of ultrasonic sensors in different environments and extreme weather conditions, as well as further testing the performance of flood early detection systems using IoT and developing sensory tools to support flood-free city planning. Another area of research is sensor optimization: Further refining sensor technology to improve accuracy and reliability, especially in challenging environmental conditions such as heavy rain or fluctuating water levels, Integration with Smart City Infrastructure: Explore ways to integrate flood warning systems with existing smart city infrastructure, such as traffic management systems or emergency response networks, to improve coordination and emergency response efforts during floods, Expand to other disaster scenarios: Explore the application of wireless sensors and fuzzy logic frameworks in detecting and mitigating other types of natural disasters, such as landslides or earthquakes, to provide comprehensive disaster preparedness and disaster response capabilities for Gresik Smart City.

Suggestions To optimize sensor accuracy under extreme weather conditions and integrate the flood-prone area warning detection system with other smart city infrastructure components, several suggestions can be implemented: Use of Highly Resilient Sensors: Select sensors that are resilient to extreme weather conditions, Calibration and Routine Maintenance: Perform regular sensor calibration to ensure accuracy of readings and routine maintenance to check and replace damaged or worn sensors. Use of Redundancy Technology: Implement redundancy by installing multiple sensors in the same location or using different types of sensors. More Advanced Data Processing Algorithms: Develop and implement more advanced data processing algorithms, such as machine learning or big data analysis. Integration with Other Smart City Systems: Integrate flood detection systems with other smart city infrastructure, such as traffic management systems, smart drainage networks, and emergency warning systems. Improved Data Communication and Connectivity: Use more reliable data communication technologies. Collaboration with Local Communities and Participation-based Risk Assessment: Engaging local communities in monitoring and reporting flood conditions and providing a platform for people to contribute with local information.

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