Flood Prevention System Using IoT

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***Abstract*—Floods are one of the most severe natural disasters in Malaysia, occurring frequently in recent years and causing significant socio-economic and environmental impacts. These recurring disasters lead to huge losses and prolonged recovery period. Flood management involves four phases: prevention, preparedness, response, and recovery. However, existing flood management systems primarily focus on preparedness, response, and recovery, often neglecting preventive measures, especially in river basin which serve as the primary channels for water flow. The lack of emphasis on the prevention phase has resulted in frequent flood occurrences, economic losses, loss of lives, and extensive environmental damage. To address this gap, this study proposes an IoT-based Flood Prevention System specifically designed for river basin management to mitigate flood risks. The system effectively regulates and maintains river water flow and quality, with the integration of Internet of Things (IoT) and Automated Water Turbines. By using real-time data collection from IoT sensors with historical flood data, the system can autonomously take appropriate actions to regulate and maintain the water flow and water level in river basin. These proactive measures allow for better water discharge to the sea, even during periods of heavy rainfall. The implementation of this system contributes to sustainable flood mitigation strategies with advanced technologies enhancing disaster management capabilities.**

***Keywords*—Flood prevention system; Internet of Things (IoT); automated water turbines; river basin management; real-time monitoring; AI-based flood prediction; environmental sustainability; smart infrastructure**

I. INTRODUCTION

Malaysia is one of the countries frequently affected by natural disasters such as flood disaster frequently in past years and causes severe impacts on people, properties, infrastructure, homes, crops, and even loss of human and animal lives. Flood management is divided into four phases: prevention, preparedness, response, and recovery. However, the current flood management system in Malaysia primarily focuses on preparedness, response, and recovery, neglecting prevention, particularly in managing river basins, which serve as the primary channels for water flow. The current system has not effectively solved the flood disaster issue over the years as the system is focusing on preparedness, response and recovery phase. The most recent flood disaster resulted in an overall loss of RM 6.1 million, where people have still suffered in their daily life even months later [1]. This highlights the need for a proactive flood management approach that focusses on prevention rather than prediction and response.

Heavy rainfall, poor river management, clogged drainage systems, and overflowing rivers are primary causes of flood disasters in Malaysia. Malaysia faces heavy rainfalls during October to December and during April month [13]. Water flows from drainage systems into rivers and streams, which then move through river basins before discharging into the sea or ocean. Disruptions occur when river basins cannot manage excessive water during heavy rainfall. At the same time, blockages and clogged rivers further restrict capacity, preventing efficient water flow. This congestion causes water to overflow, leading to widespread flooding as it has no clear discharge path to the sea. River basins function as natural channels, transporting water from multiple rivers to the sea [14]. However, during heavy rainfall, river basins are unable to manage large amounts of water where the capacity exceeded and results in congestion that triggers flash floods. This further contribute to the severity of floods in Malaysia [10]. With a well-maintained drainage system, especially river basins, the risk of flash floods can be significantly reduced, ensuring smooth water flow, and preventing water overflow.

Many countries, including Malaysia, primarily focus on preparedness, response, and recovery rather than prevention in flood management, resulting in frequent occurrences of flood. This situation has persisted for years, leading to repeated flood disasters that have caused severe impacts on infrastructure, agriculture, ecosystems, and human livelihoods. Malaysia has taken proactive measures to enhance flood forecasting and disaster planning such as National Flood Forecasting and Warning Program (PRAB) and the National Flood Forecasting and Warning Centre (PRABN). These initiatives, under the Department of Irrigation and Drainage (DID) Malaysia aim to mitigate flood risks by alerting and evacuating people in advance. PRABN focuses on more effective evacuation planning and PRAB focuses on better coordinating and real-time flood monitoring [15]. Apart from that, there are other structural and non-structural flood prevention measures, including flood control dams, river widening, bunding, and the SMART Tunnel. Although several preventive measures have been implemented, there are no strategies focusing on water flow management, especially for rivers and river basins. Effective flood prevention requires proactive measures to regulate river flow, prevent blockages and enhance capacity to ensure that there is good water flow even during heavy rainfall.

Malaysia currently lacks a flood management system to monitor, maintain, and implement proactive flood prevention solutions. Flood management consists of four phases:

prevention, preparedness, response, and recovery [16]. However, Malaysia primarily focuses on preparedness, response, and recovery, neglecting prevention. Although preparedness, response and recovery measures make a difference, the issue persists because the root causes of flooding remain unaddressed. Overcoming root causes will eventually prevent flooding from happening.

The proposed research, which is Flood Prevention System using IoT is proactive flood management emphasizing flood prevention rather than preparedness, response, and recovery. With the implementation of this system, flood risks can be significantly reduced with integration of IoT sensors and automated water turbines to regulate water levels and flow effectively. The Flood Prevention System using IoT is a real-time monitoring and proactive flood management system designed to maintain river basin levels and flow at an optimal level. It has the capability of proving high accuracy prediction on flood disasters, executing appropriate prevention steps for flood prevention by maintaining the water levels, water flow in all the river basins. The Flood Prevention System using IoT is powered by the Internet of Things (IoT) and integrates automated water turbines to regulate river flow efficiently. IoT sensors, including water level sensors, raindrop sensors, and ultrasonic sensors collect and analyze data in real-time to enhance flood prediction and prevention. Automated water turbines play a crucial role in monitoring and maintaining the water flow of the river. The automated water turbines work when the system detects the low speed of the river water. By integrating real-time data and automated interventions into the system, this system provides a proactive flood management solution preventing flood disasters.

Integration of IoT with Flood Prevention System helps to gather data from sensors in real-time without any interruption [8]. Water sensors and ultrasonic sensors were being used as IoT devices to gather water level information in real-time and data will be analyzed for flood prediction and solutions to maintain the water flow of all rivers. The constant real-time data can produce higher accuracy of results and less impact on the environment as well as people. IoT's real time data have a higher rate in minimizing the potential damage since the system implementation able to provide a best solution for the departments to serve the people [4]. At the same time, most of them are less aware of flood warnings, flood prediction or alerts because they are only getting alert when there is flood about to occur which is making them to be unprepared and becoming victim of it at the end. The lack of constant information supply between respective departments and citizens leads to have high impact during flood disaster currently. With the system, authorities and people get reliable information on the rainfall and water levels in all rivers.

There are three scenarios which are being prioritized for the flood prevention system. First, if the water level in a river is high due to less depth in water, it will alert the Drainage and Irrigation Department to deepen the river basin. Second, if the water level in a river is high due to internal or external blockage, it will alert Drainage and Irrigation Department to clear. Third, if there is water level rise and no blockages, it will turn on the automated water turbines to speed up the water. With that, instead of showing prediction and alert before flood, the system will constantly maintain the water level, water flow of all the rivers. This will make sure water flow is good all the time even though there is heavy water flow. The Flood Prevention System using IoT will be highly beneficial as it effectively addresses current flood management challenges and overcomes it by providing appropriate measures. By integrating advanced sensor technology and automated water regulation, the system able to maintain a good flow of water and optimal water level throughout the year. To provide a comprehensive understanding of the study, this paper is structured into six sections. Section II (Literature Review) provides an analysis of existing flood management approaches, highlighting challenges in current approaches and the need of advanced technologies. Section III (Methodology) details the design and implementation of the IoT-based Flood Prevention System. Section IV (Findings) presents the system's performance results. Section V (Discussion) evaluates the practical implications of the system. Section VI (Conclusion and Future Work) summarizes key findings and suggests enhancements to the system in future.

II. Literature Review

Flood disaster is one of the most threatening issues in Malaysia, affecting people, facilities, infrastructure, animals, agriculture, and more. Flood disasters are being highlighted globally, causing widespread and increasing damage to communities, economies, and ecosystems. The primary reasons for frequent flooding include heavy rainfall, poor river management, clogged drainage systems, and overflowing rivers. Flood disasters are occurring worldwide, including the 2013 Uttarakhand flash floods, 2019 Mozambique Cyclone Idai floods, 2011 Thailand floods, and 2019 Jakarta floods [17]. In Malaysia, flood issue is not being resolved over the years. In Pakistan, over 1,739 people died, and thirty-three million people were affected by the floods between June and November 2022. The economic losses were estimated at over $30 billion. Apart from that, there were another flood in Chennai, where it caused by heavy rainfall during the northeast monsoon season in November–December 2015. Malaysia also faces the same challenges, experiencing severe flooding events due to heavy rainfall, poor drainage systems, and rapid urbanization. In December 2021, prolonged heavy rain in Malaysia specifically in Selangor and Klang Valley lead to have flash flood causing huge damage including loss of property, infrastructure, and agricultural damage. The economic and social implications of these disasters emphasize the need for enhancing the current flood management system with advanced features and capabilities to prevent flood disasters in Malaysia.

The impact caused by floods, making people face more issues in becoming the flood. The recovery phase from floods is time-consuming, and people must spend significantly to rebuild their lives. While some prevention methods have been applied in Malaysia, their effectiveness and accuracy fail to keep pace with current technology and environmental demands [6]. There are several reasons why floods occur. The primary cause is heavy rainfall, particularly during the period from October to December, which often leads to flood disasters in Malaysia. Other contributing factors include poor river management, overflowing rivers, drainage blockages, and excessive exploitation of natural resources. These factors increase flood risks especially in urban areas where rapid development has impacted natural water flow. These factors increase flood risks, especially in urban areas where rapid development has disrupted natural water flow. There are several sources contributing to high water flow into rivers and river basins, such as heavy rainfall, dam water releases and poor drainage system. Heavy rainfall, particularly during monsoon seasons, causes extreme water flow, and causes flooding.

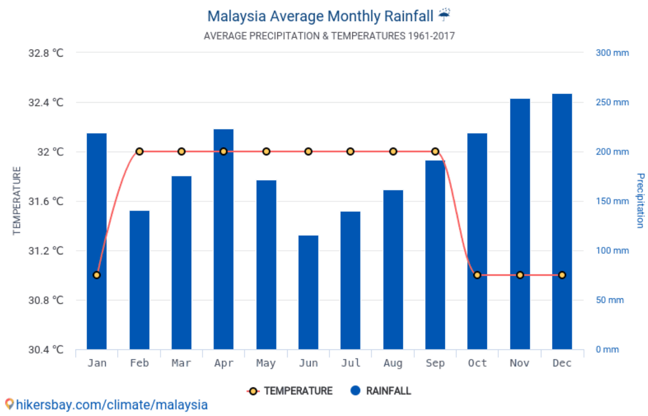

Fig. 1. Malaysia average monthly rainfall.

Fig. 1 illustrates the annual rainfall and temperature trends in Malaysia. The rainfall shows an increasing graph in October, November, December, January, and April [5]. These months have experienced heavy rainfall and high chances of flash flooding. Heavy rainfall is one of the primary contributors to flooding in Malaysia, especially in low-lying urban areas where water drainage system unable to manage large volume of water. Poor river management and sediment accumulation also causes flooding where water flow is obstructed and reducing river's capacity. Malaysia has implemented structural and non-structural measures to mitigate flood impacts. Department of Irrigation and Drainage Malaysia (DID), Malaysian Meteorological Department (MET Malaysia), National Disaster Management Agency (NADMA), Fire and Rescue Department of Malaysia (BOMBA), Department of Environment Malaysia (DOE), National Security Council, Local Government and Municipal Councils are several government agencies and departments are responsible for flood management, prevention, and response in Malaysia [19]. Structural measures include flood control dams such as Batu Dam and Semberong Dam to regulate water flow, river widening and deepening for better drainage. The SMART Tunnel in Kuala Lumpur serves as both a stormwater diversion system and traffic diversion [18]. Non-structural measures include real-time flood monitoring systems, the Greening Malaysia Programme, which aims to plant one hundred million trees by 2025, and the National Flood Disaster Management Committee.

Despite the implementation of various structural and non-structural flood mitigation measures in Malaysia, there remains a critical gap in proactive flood prevention. The existing flood management strategies mainly focus on preparedness, response, and recovery, rather than prevention. While the root cause is not being focused, the flood issue will still not be resolved. The IoT-based Flood Prevention System aims to fill this gap by integrating real-time monitoring, predictive analytics, and automated water turbine technologies. By utilizing IoT sensors and automated water turbines, the proposed system actively manages and monitors river flow in river basin, detects blockages, and ensures optimal water levels to prevent overflow and flash floods. Unlike traditional methods that only functions in preparedness, response and recovery after flooding, this system provides real-time solutions to regulate good water flow from drainage to the sea. Furthermore, the IoT-based Flood Prevention System plays a crucial role in river basin management by dynamically managing water levels in river basins.

A. Phases in Flood Management

There are four phases that can be divided into flood operations which are prevention, preparedness, response, and recovery phases. The prevention phase is to prevent floods from happening. This will ensure that there are no flood events that occur at any place. This also can be called mitigation. This is an effort to reduce the loss of life and damage the environment. Next, the prediction phase is predicting the incident on estimated date and location of flood about to occur with help of data analysis. The prediction can be made based on past flood data and other related data such as river water level data and rainfall data. With prediction, people can be flooding alert and flood warning earlier to save them and their belongings before the flood occurs. Next is the recovery phase. The recovery phase begins after floods have occurred and subsided. The purpose of recovery phase is to recover from the flood disaster and bring the affected areas and people to live a normal life [7].

B. Factors Affecting Flood Disaster

One of the reasons why flooding is happening is due to poor management of the drainage system where many drains were clogged. Apart from that, improper river management is also a reason for flooding to happen. Many rivers and river basins are being clogged because of garbage and sediments. This makes the river flow to be slower and becomes a reason for flooding. During 2018, heavy downpours and strong winds in Klang Valley caused flash floods and the reason was because of clogged drains. There was also another flood incident in Taman Selayang due to poor drainage maintenance [9]. It can be concluded that improper river management and lack of proper drainage system leads to flood disaster. When there is heavy rainfall, this makes the situation to be worse. The garbage thrown into rivers, silt and other obstructions making the drainage system lowered by 50% and causing flash flood [2]. At the end, all the clogs in drains will move to rivers and this makes the river water clog as well. Since there is no proper method to monitor the rivers and drainage by Drainage and Irrigation Department (DID), the situation is continuing for a longer period.

C. Impacts of Flooding

According to Department of Statistics Malaysia, the impact of flood is increasing, and the overall losses were RM6.1 billion which is inclusive of damages in living quarters, business premises, vehicles, agricultures, manufacturing, public assets, and infrastructure [3]. This is only the cost of losses for 2021. Each year, flood events happen very frequently, and it takes a lot of effort and money to recover from flood completely. It can be said that every year, people in certain districts suffer because of floods and it happens regularly.

D. Introduction to Flood Prevention System Using IoT

The purpose of Flood Prevention System using IoT is to conduct a prevention method to prevent flood from happening in Malaysia. The proposed system is an advanced system which has capability of providing a higher accuracy on flood disasters and making prevention from flood occurrence. The proposed system has been enhanced with Internet of Things (IoT). The purpose of IoT is to improvise the prediction of flood by using additional data which is collected using sensors. Sensors that are integrated with the system are water depth sensor, soil moisture sensor, rainfall sensor and ultrasonic sensor [11]. This system is also included with automated water turbines. Water level sensors are used to measure the depth of river water. Rainfall sensor is used to measure the rainfall. Ultrasonic sensor is used to detect the water wavelength and identify any objects which are distracting the water flow. Apart from sensor, the system will be equipped with automated water turbines to increase the water flow of river.

There are four phases that can be divided into flood operations which are prevention, preparedness, response, and recovery phases. Existing systems have highlighted the preparedness, response, and recovery phase where prevention phase have been neglected. The purpose of the proposed system is to enhance the prevention phase by implementing IoT and AI technology. In Malaysia, the system that is implemented by authorities has more focused on prediction where they are using the flood history data and rainfall data to predict the flood. After prediction, they will alert the people to evacuate to safer places and protect their belongings [23]. This scenario has been implemented and has been implemented since a long time ago. Although this situation can save life and their belongings, the accommodation, infrastructures and facilities are being destroyed because of flood. Because of this, the government needs to execute plans to get the situation back to normal and this results in people spending huge amounts of money.

The current system can protect a few percentages of damage but still it is affecting people and the environment. With that, the proposed system is focused on the prevention phase where the results will 99.9% flood prevention [12]. By implementing the proposed system, flood disasters can be avoided, and many things can be saved. Implementation of IoT such as rainfall sensor, water depth sensor, soil moisture sensor and ultrasonic sensor able to provide a higher accuracy data on river water level. Higher accuracy of data helps in maintaining river water flow and helps in better prediction. Below are steps on how the proposed system works to prevent floods.

1) IoT sensors such as rain drop sensors, water level sensor, and ultrasonic sensor will be integrated with the system and the system will be monitoring all the sensor and collecting the data.

2) With rules or statements set, the system can analyze and interpret the data. The system will set the optimum water level in each river to ensure that there is good water flow in rivers even though there is flood disaster.

3) When the river water level is continuously giving a reading that is more than optimum level, the system will identify the cause of the effect.

4) If the higher level of river water is caused by a slowdown in water flow due to blockage, it will alert the Department of Irrigation and Drainage to clear the blockage.

5) If the higher level of river water is caused by less depth in river, it will alert the Department of Irrigation and Drainage to deepen the river.

6) The system is equipped with water turbines, where it will work simultaneously with a microcontroller and water depth sensor. When the sensor detects the slowness of the water level, it will automatically trigger the water turbine to turn on. With this, the water flow can be increased.

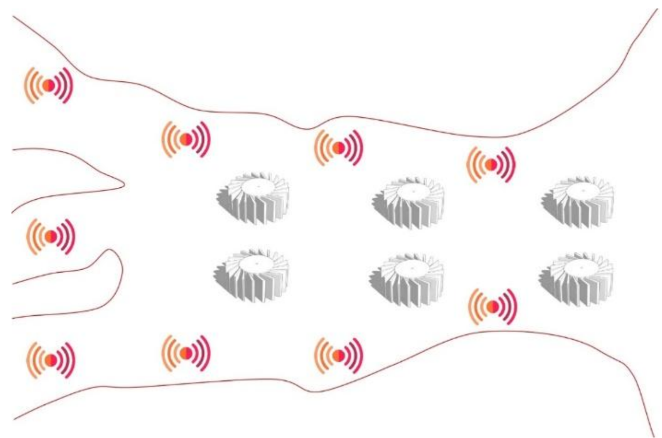

Fig. 2. Proposed system.

Fig. 2 illustrates how the proposed system will look like. The Flood Prevention System using IoT emphasizes the prevention phase. The system will be integrated with IoT sensors such as water level sensors, rainfall sensor and ultrasonic sensor. Apart from that, it also includes water turbine technology which will increase the flow of water rivers when it is necessary. The IoT sensors will be placed on river basins where it is able to detect the flow of the river water. When there is no blockage and the water level rises, then it will activate the water turbine. Water turbines will be automated when there is a requirement to increase the flow of the river water with the integration of IoT. Automated water turbines allow the river water to be cleared as quickly as possible to be sent to the sea. It means that there will not be any water traffic at the river basin, and it will ensure that water from the drainage will be quickly sent to sea.

When this system being implemented, it can be concluded there is no reason for clogged drains and rivers. Even if there is heavy rainfall, the river water will be constantly sent to sea, and this will prevent flooding. All the integrations and the systems will ensure that the data is collected precisely, and actions will be taken accordingly.

III. METHODOLOGY

A. Research Problem

The Malaysia is one of the countries which is affected by natural disasters such as flood disaster frequently in past years and it creates huge impact on people, properties, infrastructures, houses, destruction of crops, loss of human life and animals. In terms of flood operation, there are four phases which are prevention, preparedness, response, and recovery phase. In

Malaysia, the system which is implemented by authorities only focusing on preparedness, response, and recovery phase. Preparedness, response and recovery phase will not be helpful because somehow the damage is still there, but people are affected by damages. The current system is not highly effective because the flood disaster issue has not been solved over many years. The recent flood disaster has caused 6.1-million-ringgit losses overall and people are still suffering in their daily life even though the flood disaster happened few months [20]. This proves that people are still getting to be affected even if there is preparedness, response and recovery actions conducted.

The main reason for having flood is because of heavy rainfall in certain period of time and clogged drainage systems. It has been identified that Malaysia faces heavy rainfalls during October to December and during April month. Clogged drainage system, poor river management, overflowing rivers are some of the main reasons why there is flood disaster happening in Malaysia. When there is a clogged drainage system, the water flow in rivers become slower. When heavy rain hits the ground, the river basins will have water traffic, and this will lead to flash flood. When there is proper system to maintain the drainage system, there is no worry for flash flood in future.

Not only in Malaysia, but most of the countries are focusing on preparedness, response, and recovery phase too. This situation has been happening for the past few years, the results are repeating the same which is huge damage to all.

Moreover, there is no proper communication platform before and during flood disasters. People are not getting sufficient information regarding the latest updates, and this causes a lack of communication between people and authorities. The current technologies have made many improvements in many sectors. With that, Implementation of new technologies and automated responses will be able to solve this entire issue. The proposed research is AI powered Flood Prevention System using IoT which is focusing on prevention phase. With implementation of this system, flood prevention can be 99.9% of successful rate with help of IoT sensors and automated water turbines.

B. *Research Methodology*

For this research, quantitative methodology is the most appropriate methodology which can be used to collect data information on the problem faced by the target audience. Quantitative Methodology can be described as exploration of numeric patterns with help of description on the characteristics, hypotheses from a group number of people. This methodology is usually when there is involvement of large number of people in issue. Quantitative methodology can be conducted with the help of questionnaires, surveys, and statistical data. Since it involves large number of people, it will be helpful and easier to gather data such as opinion, ideas, feedback from people. Gathering data from people is important to ensure that the system that is being proposed able to satisfy their needs, able to solve their current issue and provide a useful solution to them. By doing quantitative methodology, researcher able to understand the problem from audience side, and how they are encountering the problem in their daily life.

There are few benefits of conducting quantitative methodology. First, the researcher able to clearly understand and define the research question accordingly, so that data that to be collected will be precise and fit to the purpose. Since it involves a large group of people, the results can be easily represented in the form of a table, chart, or graph. Since the questions and answer options are set by researcher, it is easier to understand people's opinion. Secondly, the data that is collected can be easily documented in graphs, charts, tables instead of text. This makes it easier for researcher to have good understanding on the issue and at the same time, researcher can analyze the problem from different perspective and view. For this flood disaster issue, questionnaire will be the most suitable technique to understand the issue from the target audience and analyze it.

Questionnaires are one of the useful ways of collecting data from large group of people. This can be a quicker and easier method of data collection. Since the target audience is large for the proposed system, a questionnaire is suitable way. The questions that are prepared for the questionnaire are very important and detailed because there will not be physical interaction with the person. The questionnaire will not be like an interview session because the person is only going to fill in the form based on the questions and answers given. The questions can be multiple choice question and open-ended question.

C. *Target Audience*

The target audience for this research will be aged, more than twenty-five. The number of respondents that will receive questionnaire will be 35. The reason the age group is selected for more than twenty-five is because they will have more knowledge and clarify the current issue faced by people. At the same time, more than twenty-five aged people are mostly households which means they will be handling family members. With that, they tend to understand more about flood issue and how they are handling floods disasters. Next, the reason thirty-five people is selected as respondents because the flood disaster issue is almost faced by most of the states in Malaysia. Since there is large number of people exposed to flood, thirty-five people will be sufficient to gather information for analysis.

D. *Variables*

The Table I shows the variables that have been identified in the research. The manipulated variable for the proposed system will be the clogged particles in river and responding variable will be the speed of water flow in river. It is because when the clogged particles in drainage, river basins and river increases, the speed of water flow in river will decrease [24]. When this situation happens, this is where flood disaster occurs due to presence of heavy rain since there is no proper water flow of river to the sea.

TABLE I. VARIABLES

Variable	
Manipulated Variable	The quality of river water
Responding Variable	The water flow speed in river
Constant Variable	The IoT sensor and Water Turbines

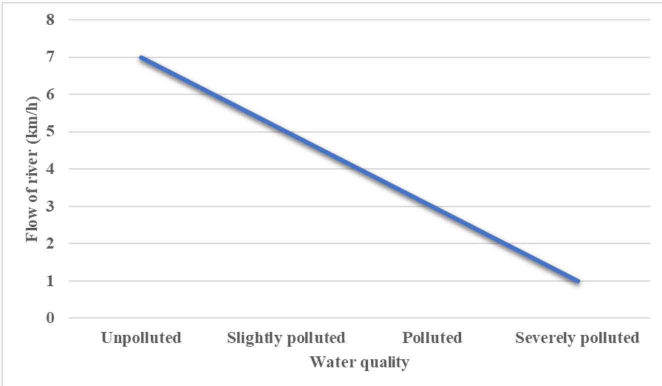

Fig. 3. Effects of water quality on speed of river water.

Fig. 3 illustrates how the water quality affects the speed of river water. When the quality of air turns bad, the flow of river water will decrease which eventually causes flood disaster to occur.

E. *Summary of Analysis*

Based on the questionnaire conducted with thirty-five respondents, it can be concluded that people are aware of the cause of the flood. Respondents able to understand the cause of the flood which results in frequent occurrence of the flood. Apart from that, the information collected through the questionnaire can be useful to analyze on the user's perspective towards flood events. Moreover, the information provided will be useful to improve the proposed system to a better state. At the same time, they able to understand and accept the purpose of the proposed system. Respondents able to get to know the flow and outcome of the proposed system. With that, it can be concluded that the objective of the proposed system is achieved, and the proposed system will be helpful to everyone when it is being implemented.

IV. FINDINGS

Flood control has become a crucial issue in a society that has taken a remarkable step to manage this disaster by implementing a Flood Prevention System that utilizes Internet of Things (IoT) technology. This technique is a ground-breaking method of reducing flood damage and has the potential to significantly advance the field of sustainable development. Malaysia's Flood Prevention System goes beyond traditional flood control techniques. The proposed system creates a proactive approach by IoT sensors strategically along river basins, as opposed to just responding to flood disasters. Essential characteristics including river flow rates, precipitation patterns, and water levels are continuously and instantaneously monitored by these sensors such as rain drop sensor, ultrasonic sensor, and water level sensor. With the data collected by IoT, it acts as an essential instrument for informed decision making, enabling decision-makers to take wise decisions intended to protect living creatures and the environment without being damaged.

A. *System Architecture*

The Flood Prevention System's architectural design offers a comprehensive and effective method of managing and mitigating flood disasters. This framework consists of an Internet of Things (IoT) sensors that are placed strategically along river basins and drainage systems. These sensors continuously collect information in real time about river flow rates, water levels, and the state of the environment. Examples of these sensors that are being integrated are ultrasonic sensors, rain drop sensors and water level sensors [21]. Once the data is collected from the sensor, it is sent to the central processing unit (CPU), it will be analyzed and act accordingly according to the rules set. This analytical procedure helps in risk assessment and flood event prediction. Automated water turbines have been seamlessly integrated into the system to further improve its capabilities. By integrating this into the system, this allows the system to control the water flow in the rivers.

The main purpose of the automated water turbines is to boost up the flow of water when there is a rise in water level. When there are high chances of flooding and to prevent floods, these turbines quickly increase river flow rates based on the insights gained from data analysis. The main purpose of the automated water turbines is to increase the flow rate of water in river basins, ensuring that excess water is efficiently moved to the sea and there is no backflow of water. This functions as water regulator with integration of IoT sensors. When IoT sensors detect rising water levels, the system evaluates whether the water flow is slower than the optimal rate. At the same time, if the water rise or water slow rate is not because of blockages, then the turbines are activated to accelerate the water flow towards larger water bodies such as sea. The automated control system ensures that there is balanced water level and water flow with real-time sensor feedback.

In addition, the architecture includes a strong communication and alerting system that guarantees relevant authorities are notified and alerted accordingly. Every process happens in a timely manner when a flood hazard appears. This feature makes it easier to respond quickly and put preventative measures in place. With inclusion of IoT sensors into the system, it creates a strong basis for efficient flood prevention, ultimately protecting and preserving the infrastructure, human life, and the environment. This makes human life easier by not creating any hustle in case there is high rain rate in a place.

Fig. 4 illustrates the system architecture of the flood management system. Data collection will take place from IoT sensors such as water level sensors, ultrasonic sensor, and raindrop sensor. The data collected from the IoT sensors is sent to a CPU, which processes and analyzes the information [22]. The CPU uses rules and algorithms to interpret the sensor data and make decisions based on predefined terms. Simultaneously, the system communicates risks and sends alerts and at the same time, controlling the water turbines.

B. *Hardware and Software Requirements*

Flood prevention system is an innovative method for efficiently managing water resources and avoiding flood disasters. The main component, an Arduino Compatible DCCduino Uno R3 microcontroller, is used to manage a network of actuators and sensors. The HC-SR04 and waterproof JSN-SR04T are two ultrasonic sensors that are essential to the system's operation because they provide accurate water level measurements in both submerged and non-submerged conditions. Both sensors are used to detect any blockage throughout the system operation. A rain sensor module provides real-time weather and rainfall detection, and a dedicated water level sensor module keeps an eye on water level in the river basin. With integration of switch relay module, the system's intelligence is extended to water pump control, with R385 DC 12V Pneumatic Diaphragm Water Pump. It represents as automated water turbine to speed up the frequency of river flow rate.

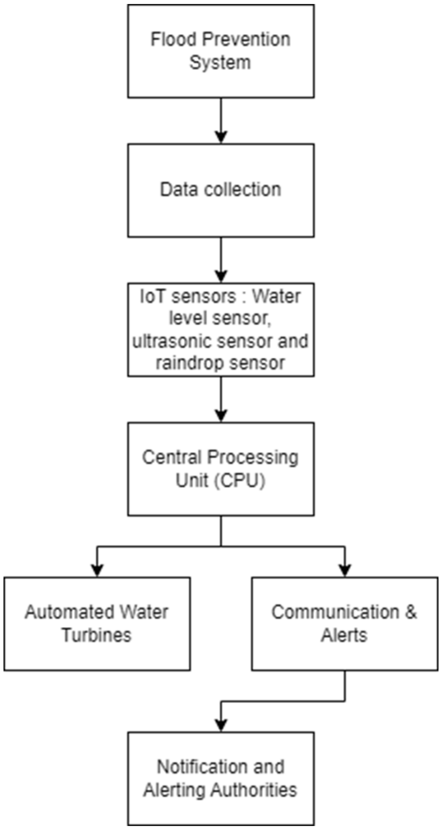

Fig. 4. System architecture.

In addition, the system incorporates effective communication features that allow for instant SMS notifications with the integration of SIM900A module. A 16x2 character LCD display with an I2C interface makes the water levels visible and it is easier to observe the system's status. A 5V 2A power supply adaptor is included to ensure that the water pump receives steady and dependable power delivery. With this integration of better sensor modules and water pump, it allows for proactive water level monitoring, and at the same time maintains the flow of the river by controlling the water pump automatically. The system's capacity makes necessary action by sending notifications to a respective department contact numbers which makes better valuable output for everyone. This creates the best tool to manage the river water effectively and prevent floods from happening.

C. Connection Schema

Fig. 5 and Fig. 6 illustrate the connection schema and breadboard view which shows hardware configuration and physical representation of the component in IoT-based Flood Prevention System. The schematic diagram (Fig. 6) provides a detailed circuit representation of how the components are electrically connected.

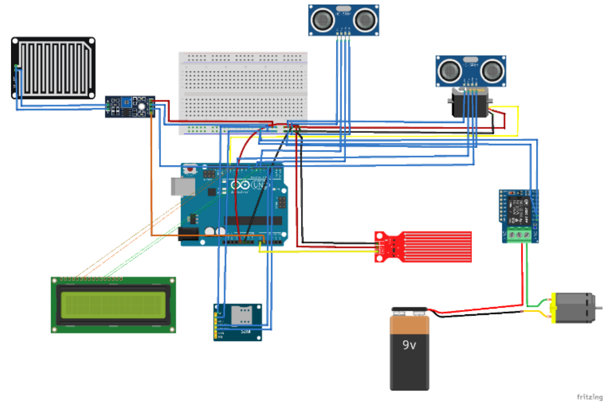

Fig. 5. Breadboard view.

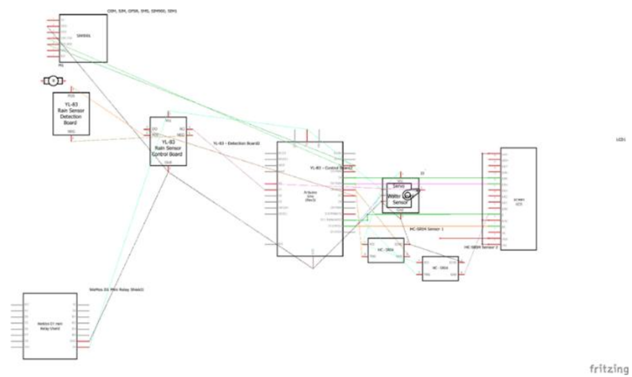

Fig. 6. Schematic diagram.

TABLE II. IoT Sensors and Component Connection

Sensor/Component	Specific Sensor/Module	Arduino Pin
Water Level Sensor	LCD I2C (SDA)	A4 (Analog 4)
	LCD I2C (SCL)	A5 (Analog 5)
	Water Level Sensor	A0
	Relay Module	4
Internal Ultrasonic Sensor	SR04M-2 Trigger Pin	5
	SR04M-2 Echo Pin	6
	SIM900 RX (SoftwareSerial)	2
	SIM900 TX (SoftwareSerial)	3
External Ultrasonic Sensor	Ultrasonic Trig Pin	10
	Ultrasonic Echo Pin	11
	Water Level Sensor Pin	A0
Rain Drop Sensor	Raindrop Sensor	Digital Pin 7
Automated Water Turbines	Relay Module	Digital Pin 4
	COM	Power Supply
	NO	Water Pump
	NC	-
SIM Module	SIM900 RX (SoftwareSerial)	2
	SIM900 TX (SoftwareSerial)	3
Common Connections	VCC	5V
	GND	GND

Table II presents the IoT sensors and component connections used in the Flood Prevention System using IoT. Each component has its own roles and connections to provide real-time data for flood monitoring and automation interventions.

V. Discussion

A. *Evaluating the Effectiveness of Flood Prevention System*

The flood prevention system using IoT is one of the most advanced approaches to tackle the flood. Instead of predicting floods or recovery planning after flood, it analyzes the data from the IoT sensor and makes the right solution to prevent the flood from happening. The purpose of our study was to evaluate the suggested flood prevention system's efficacy. The results verify that the goals of the system have been effectively accomplished. One important finding from the study is that the suggested flood prevention strategy into practice will have immediate benefits. There is a higher success rate which can significantly stop property damage and save lives. Furthermore, the system's incorporation of IoT sensors helps in gathering accurate data for well-informed decision-making, including sensors for water blockage and rainfall. These sensors deliver high-quality data, which is essential for timely action and preventative flood mitigation.

There are several crucial areas where the system's implementation can have a positive influence. One of it is, the system can greatly lessen the harm that floods does to the ecosystem. The system's ability to prevent flooding can aid in the preservation of natural areas. Next, it can protect human and animal lives as the system can prevent flooding directly save lives. Efficient data gathering, processing, and response actions are some of the factors which can make the system perform better. To improve flood prevention, automated water turbines are essential in controlling water flow based on real-time data. These turbines are essential for reacting to changes in water levels. Automated water turbines help increase the flow of water from river basin to the sea when there is flood detection.

These sensors, which include raindrops, ultrasonic, and water level sensors, function as tools to provide continuous monitoring on the surrounding environment. The success of the system is largely dependent on its accurate data collection. Apart from that, integration of SIM Modules, strategically used to improve communication inside the flood prevention system. These modules give the system the ability to notify specific departments via SMS based on the scenarios. The SIM modules provide a dependable communication route for informing authorities about water turbine activation, warning users of blockages, or providing a warning of prolonged rain.

With that, this can be concluded that flood prevention systems can have tremendous potential for managing and mitigating flood disasters. By overcoming the limitations and integrating future enhancements, the system can become an effective tool for responding to and preventing floods.

B. *Contributions to Sustainable Development Goals (SDGs)*

The utilization of IoT in Malaysia's Flood Prevention System signifies an innovative method for mitigating flood calamities and making substantial progress towards attaining various Sustainable Development Goals (SDGs). This system incorporates advanced technology and forward-thinking tactics, and it is worth exploring how it aligns with and contributes to the objectives of SDGs 6, 11, and 15.

SDG 6: Clean Water and Sanitation

The fundamental human right to access clean and safe water is a central focus of the Flood Prevention System. It plays a crucial role in upholding this right by constantly monitoring key water parameters like water levels, river flow rates, and rainfall patterns via IoT sensors. This continuous data monitoring and analysis empowers authorities to make well-informed decisions, preventing water contamination during flood incidents and relieving the overall burden on clean water resources. Consequently, it harmonizes seamlessly with the core objectives of SDG 6, which revolve around ensuring universal access to sustainable water and sanitation services.

SDG 11: Sustainable Cities and Communities

With the rapid pace of urbanization, cities worldwide face growing susceptibility to climate-induced disasters such as floods. The Flood Prevention System emerges as a substantial contributor to the realization of SDG 11 by bolstering the resilience of urban areas. Through its provision of timely flood alerts and facilitation of swift responses, the system actively fosters the development of secure, inclusive, and sustainable cities and communities. SDG 11's overarching goal is to enhance urban resilience to natural calamities, elevate urban planning standards, and establish sustainable living environments. The Flood Prevention System's capacity to mitigate flood impacts and safeguard communities aligns directly with these objectives.

SDG 15: Life on Land

Floods have the potential to inflict substantial harm on terrestrial ecosystems and biodiversity. The Flood Prevention System's primary objective of averting floods and mitigating their adverse environmental repercussions seamlessly aligns with the principles of SDG 15. Through its capacity to curtail the disruptive consequences of floods, the system actively contributes to the preservation, rehabilitation, and sustainable utilization of terrestrial and inland freshwater ecosystems. SDG 15 is designed to arrest and reverse land degradation, mitigate biodiversity loss, and ensure the sustainable stewardship of forests and other terrestrial resources. The system plays an indispensable role in advancing these objectives by averting the degradation and devastation of land stemming from recurrent flood incidents.

C. *Limitation*

The flood management system discussed here serves as a valuable resource for observing and addressing shifts in environmental conditions. However, it has its limitations, like any other technology, which must be acknowledged and taken into consideration.

A significant limitation that the flood management system encounters is the accurate monitoring of the river basin's depth. While the system demonstrates proficiency in measuring water levels and promptly detecting blockages, obtaining precise depth readings for the river basin presents a considerable challenge. This challenge primarily arises from the unavailability of a suitable sensor designed specifically for depth measurement. The system relies on ultrasonic and water level sensors, which are well-suited for their intended tasks but are not inherently designed to provide the highly precise depth measurements necessary for gaining a comprehensive understanding of the river basin's conditions. These sensors primarily excel at detecting the distance between the sensor and the water surface or any potential obstructions within their operational range. The current reliance on ultrasonic and water level sensors may yield valuable insights into water levels and blockage detection, enabling timely responses to critical situations. To address this limitation effectively and gain a more profound understanding of the river basin's dynamics, it becomes crucial to consider the integration of a dedicated depth sensor or the exploration of alternative depth measurement methodologies.

Another major constraint is associated with the utilization of 2G technology within the SIM900A module. As the telecommunications landscape advances with the widespread implementation of 4G networks, relying on 2G connections can introduce certain limitations in terms of reliability and efficiency. The potential inadequacies of 2G networks become particularly pronounced in scenarios where robust and seamless connectivity is essential. Nevertheless, due to budget constraints or other resource limitations, upgrading to more advanced SIM modules that are compatible with 4G networks may not be a feasible option. Consequently, this limitation occasionally results in connectivity challenges, potentially affecting the system's capability to transmit critical alerts and updates in a timely and consistent manner. The flood management system finds itself navigating a delicate equilibrium between cost-effectiveness and measurement precision.

Additionally, it is crucial to address the matter of sensor accuracy as another noteworthy limitation. The flood management system has been designed with cost-effectiveness in mind, utilizing affordable components to maintain economic feasibility. However, these economic components can sometimes exhibit limitations when it comes to the accuracy of their measurements. These sensors are meticulously engineered to deliver precise data, making them ideal for applications where measurement precision is paramount. However, the adoption of such high-end sensors may not always align with budgetary constraints and cost-effectiveness considerations. The flood management system's sensors, which are engineered to balance performance and cost-effectiveness, may exhibit a degree of measurement variance. This variance is influenced by several factors, including sensor calibration, environmental conditions, and the inherent characteristics of the sensors themselves.

D. Future Enhancements

There exist multiple opportunities with substantial potential for enhancing the flood management system in the future. The primary imperative is to address the limitations associated with depth monitoring. This necessitates the integration of sensors explicitly engineered for precise measurement of the river basin's depth. By augmenting the system's proficiency in assessing depth, it can take proactive measures to identify situations where the depth falls below acceptable levels [27]. This enhanced capability would enable the system to promptly inform relevant authorities, such as the Department of Irrigation and Drainage, significantly bolstering its effectiveness in mitigating flood risks.

Secondly, the integration of Artificial Intelligence (AI) holds great promise. By incorporating AI systems, the flood management system can analyze and interpret data from IoT sensors more intelligently [25]. This enables it to make data-driven decisions and respond dynamically to changing environmental conditions, thereby improving its overall efficiency. Leveraging AI's power, the system can move beyond simple threshold-based alerts to perform advanced data analytics in real-time. AI algorithms can identify patterns, anomalies, and emerging flood risks, providing more proactive and adaptive flood management solutions. This enhancement harnesses the potential of IoT sensors and data analysis techniques to bolster the system's ability to monitor and respond to evolving environmental conditions.

The concept of a fully automated flood prevention system introduces a futuristic vision. This advancement entails the deployment of robots or automated tools with the capability to execute essential tasks such as debris removal, sensor maintenance, and emergency responses without the need for human intervention [26]. This automation not only enhances efficiency and response times but also mitigates the risks associated with human involvement in hazardous flood situations. However, by incorporating robots or automated equipment, the system can achieve a higher degree of autonomy. These robots or tools can be designed to perform tasks such as debris removal, sensor maintenance, and even emergency response actions without requiring human presence on-site. This transition to an automated flood prevention system can enhance the system's efficiency, reduce response times, and minimize risks associated with human involvement in potentially hazardous flood conditions.

VI. CONCLUSION

Flood disaster is one of the natural disasters that frequently affects people in Malaysia. The impact of floods not only damages the environment but also consumes lives. A proper solution needs to be implemented to address the flooding issue instead of complaining every time. The prevention phase must be emphasized, as only a well-structured prevention system can resolve this issue entirely. The AI Powered Flood Prevention System using IoT is proposed to overcome the flood issue. This system aims to prevent floods by maintaining river water levels and managing drainage systems.

Currently, many river basins face clogged drainage pathways and river basins, leading to improper water flow to the sea, which results in flooding. In conclusion, proper river flow can entirely solve this issue, as rivers serve as the primary pathways for diverting rainfall to the sea. The Flood Prevention System collects real-time data with integration of IoT sensors, while AI integration analyzes this data and performs the required actions. Additionally, automated water turbines maintain river water flow and increase it when necessary. With the implementation of the AI Powered Flood Prevention System using IoT, the flood issue in Malaysia can be completely prevented, creating a flood-free environment.

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