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Water Level Sensor Design using Waste Plastic Bottle for Rice Fields Monitoring Based on Internet of Things

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ABSTRACT

Indonesia is located at the latitude of the equator so that the area has a tropical climate. Due to this geographical position, due to this geographical position, Indonesia only has two seasons, namely the rainy season and the dry season. In the dry season, and low rainfall allows for catastrophic drought. The number of drought events fluctuates every year; it is difficult to predict. When a drought occurs, clean water assistance to the community is quite late, because there is no system in the government to monitor ability in each region. Delay in water assistance will result in losses for the community, its impact on the economy and health. So that technology is needed for the process of monitoring the availability of water in the community. This research aims to design a water availability monitoring system by utilizing internet of things technology, where this technology will detect the availability of water with sensors, then the data will be sent to the server and forwarded to user applications, namely the community and government. The results of this study have produced a prototype of a water level measuring hardware circuit and a water reservoir prototype. The test results show that the measurement results are quite accurate.

Keywords: Rice Field, Drought, Iot, Monitoring, Waste Plastic.

I. INTRODUCTION

Increasing human population and food demand and industry needs resulted in substantial pressure on land resources. Dry regions in developing countries occupy about 41% of Earth's land area, and are home to 2.5 billion people and 1.5 billion cattle while having limited natural resources and face serious environmental constraints that tend to deteriorate as a result of climate change. That is the reason why agriculture resource management is so important [1].

This is an effort to increase food security as well as to become an export commodity. Food security is the ability to access adequate food and safe and adequate nutrition, to maintain a normal and healthy life. This greatly affects the development of the nation. There are three main areas of concern, including food availability, accessibility to food, and food use [2]. So, one example is using internet of things technology to monitor rice farming land [3].

Disaster is an occasion or arrangement of occasions that debilitates and disturbs the life and job of the community which is caused, either by normal components and/or non-natural components or human components, coming about in human casualties, natural harm, property misfortune, and mental effect [4]. Based on this definition, disasters are divided into three types based on their causes, namely natural disasters, non-natural disasters and social disasters. Fig. 1 shows the trend in the last 10 years, 2010 - 2019 the number of disasters in Indonesia based on the type of disaster. Thus, natural disasters also have a major impact on rice yields.

Based on Fig. 1, the number of natural disasters is higher than others, 92.95% of disasters in Indonesia are natural disasters, the rest are non-natural disasters and social disasters. Based on their characteristics, natural disasters are divided into two, namely geological and hydrometeorological disasters [5].

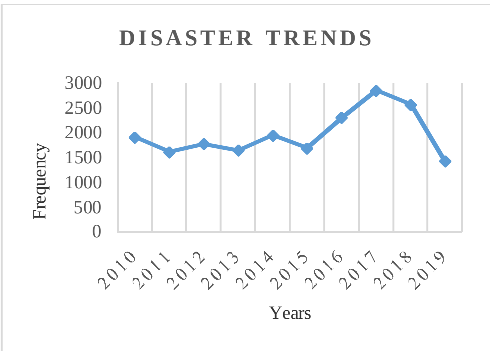

Fig. 1. Disaster trends in the last 10 years

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Geological disasters are disasters caused by plate activity or geology, while hydrometeorological disasters are disasters caused by water and/or weather/climate. Drought is one of the types of hydrometeorological disasters. Drought is a condition of lack of water supply from rainfall for a certain period, usually one season or more, which results in a shortage of water for some activity sectors, groups or the environment [6].

The number of drought disasters from 2010 to 2019 has reached 786 incidents. Figure 3 shows a graph of the trend of the number of drought events in the last 10 years. Drought also affects rice yields because rice is a plant that initially requires a lot of water. Water is also needed for fertilization and various other treatments. In essence, the need for rice must be adjusted according to the dose, neither too much nor too little. Several strategies have been taken to optimize agriculture by using the concept of integrated irrigation, in which the irrigation river flow can also be installed with a water level meter to monitor the need for water entering the rice fields [7], [8].

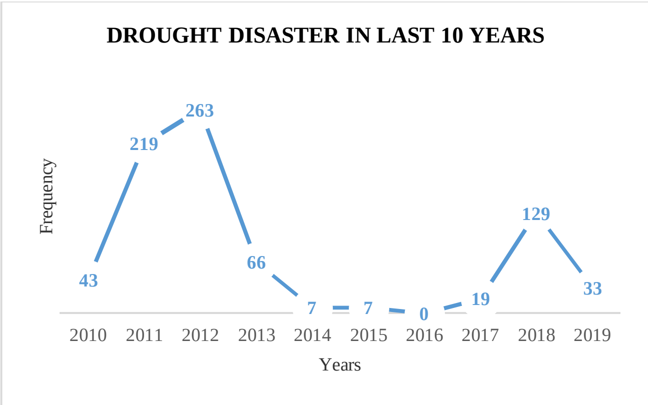


Fig. 2. Drought Disaster trends in the last 10 years

Fig. 3.

Based on Figure 2, the number of incidents of drought has fluctuated, from year to year the number is uncertain, some are large and some do not exist at all. This is due to the difficulty in predicting the weather or climate in Indonesia, both the rainy and dry seasons. This makes it difficult for the community, government and Regional Disaster Management Agency to anticipate drought disasters, so that often delays in water assistance when a drought occurs, people have to take the initiative themselves to seek assistance or find their own water for daily needs [8].

Water is a very vital need for humans, both for daily needs and for moving the wheels of the economy. Agriculture and health are the areas most affected when there is a lack of water. Due to limited drinking water resources, intensive cash needs, growing population, urban changes in rural areas, and excessive use of marine resources for salt extraction have significantly worsened the quality of water available to people.

It requires the technology used to monitor water availability, so that there are no delays in meeting water needs. Internet of Things (IoT) is a cutting-edge internet development that integrates various hardware devices such as actuators, sensors and services to support a variety of applications. The main purpose behind the IoT-based platform is to connect advanced communication tools to support the city administration's value added services for citizens. Several studies have succeeded in designing and implementing technology for water monitoring by utilizing IoT technology. Research [9] proposed a prototype system design, implementation and description of the tools and technology needed to develop an Internet of Things (IoT) based water level monitoring system that can be implemented in smart villages in India. Meanwhile, research [10] proposes the design and implementation of an IoT platform for monitoring water quality in lakes. With the use of the internet of things (IoT) platform with visual analytics (VA), a real-time water consumption monitoring system has been developed for household and commercialized building applications [11]. Research [12] proposes IoT for flood monitoring, so that it can protect villages and cities. Based on previous research, IoT can be used to monitor water conditions, both water availability and water quality. So, this study proposes to design a system architecture to monitor the availability of water in water sources in the village, such as rice fields, wells, and water availability in rice fields.

II. Research Methods

2.1. Observation and Data Collection

This observation is a method of collecting data by observing directly. At this stage, data collection will be carried out by taking evidence of some news from the TV station and data from the National Disaster Management Agency (BNPB) by observing directly the condition of the rice field so that it can be used as a sample later in the trial stage. In this research, the research took place on the rice field in Bojong Village, Kawunganten District, Cilacap, Central Java. The research period starts from September 2021 to Desember 2021.

2.2. Hardware Components

Hardware design is needed to provide a clear and complete picture for later use in making computer programs. In hardware design, the ESP8266, Ultrasonic Sensor, and Arduino are connected. Arduino functions as a microcontorler controlling ultrasonic sensor and wifi module, Ultrasonic sensor as a distance measure from the water surface to the measuring place, then the water level is calculated from the bottom to the water surface, the data is channeled to Arduino and then sent to the server with the help of ESP8266 wifi module. Fig. 3 shows the main components used to measure the water level from the bottom to the water surface. The use of arduino also works for the long term if it is connected to many sensors, the available I/O ports are still sufficient.

Fig. 4. Main hardware components from left to right side: ultrasound sensor, ESP8266 and arduino

Fig. 5.

2.3. Sensor Design and Manufacture

A prototype is a visual design that describes a product developed before it is made on an actual scale or before it is mass produced. After the main hardware design stage, it is then continued to make a prototype of a place to simulate as a rice field in order to find out how the main hardware works in measuring water level.

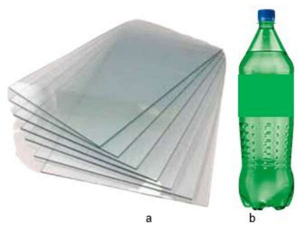


Fig. 6. Main components of water sensor prototype (a) glass aquarium (b) plastic bottle

Fig. 4 shows the main components for making rice field simulations, aquarium glass will be assembled in blocks to accommodate water, and plastic bottles are used to assist ultrasonic sensor in measuring water levels. The materials used come from waste that is available quite a lot in the environment. This plastic waste is very difficult to decompose by micro-organisms, so that over time it will become soil pollution. Given the dangers of such waste, the use of plastic bottle waste will reduce the impact of environmental pollution. The use of plastic bottles aims to measure the water level more precisely, because it can simulate the calmness of the water in the bottle, compared to the sensor being directly directed to the water without the aid of a plastic bottle.

2.4. Monitoring Dashboard Design

The water level monitoring dashboard is designed based on a website, the dashboard is used to display the results of measuring the water level in the rice fields, the data captured by the sensor, is forwarded to Arduino to be processed, then forwarded to the server and stored in the database. Data from the database will be displayed in real time on a website-based dashboard. In designing the dashboard, a server is needed as a hosting and a domain.

III. Results and Discussion

3.1. Hardware Design and Manufacture

The second step in this research after observation and data collection is designing the hardware design. In the previous chapter, the main components of the hardware used have been discussed, this section describes the results of the hardware circuit. Before assembling the hardware components, the previous step is compiling the design of the hardware components used. Fig. 5 shows the results of the Arduino circuit and breadboard design, ultrasonic sensor, and ESP8266 Wifi Module, the three components are connected with the help of a breadboard and a jumper cable. Meanwhile, Figure 6 shows the results of the breadboard design implementation of the component circuit design.

The data stream starts from the sensor, then is read by the Arduino and sent to the ESP8266. After that the data is sent to the server via ESP8266. The communication used from Arduino to ESP8266 uses UART (Universal Asynchronous Receiver-Transmiter) communication. This communication runs serially using the Tx/Rx port. Data reading is done continuously with delay of about 6 seconds.

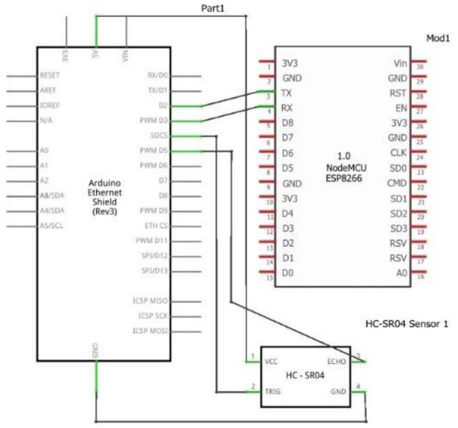


Fig. 7. Breadboard design

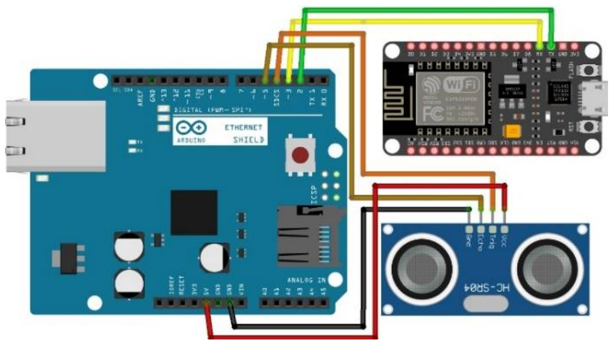


Fig. 8. Breadboard design

3.2. Sensor and Prototype Design

To simulate a rice-fields, we made a prototype from the basic material of aquarium glass. In this prototype, there is a series of main components of hardware that functions to detect the water level. The ultrasonic sensor is installed on top of the plastic bottle, while the Arduino and ESP8266 WiFi Module are stored in a black box to make it look neat. The electric power used in this prototype is by using a power bank connected by a USB cable. Fig. 7 shows the prototype results in this study.

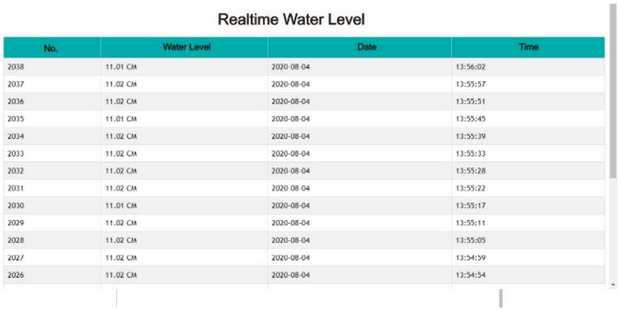
The use of glass is intended so that the movement of water entering the bottle does not cause ripples, thereby minimizing noise when measuring using an ultrasonic sensor. However, in the long term the use of glass base materials is certainly not efficient, the costs incurred are relatively high. Further research can be tested with a plastic bottle design with a hole in the circular side. The size of the small hole is adjusted to the diameter so that the movement in the bottle is not too rippled.

Water resistance is one of the important things for the durability of the sensor, considering the use of this sensor in open spaces. In this study, we have not used waterproof insulation on the sensor, but for further research it can be recommended asphalt or rubber insulation as the top cover of the sensor or the mainboard part of the ultrasonic sensor.

Fig. 9. Sensor and prototype design

3.3. Interface Design

Website-based dashboards are used to display the results of measuring the water level in the water reservoir. In addition, it is used to test the accuracy of the hardware circuit prototype in measuring the water level. Fig. 8 shows a website-based dashboard used for monitoring water levels.



Realtime Water Level

No.	Water Level	Date	Time
2038	11.01 CM	2020-08-04	13:56:02
2037	11.02 CM	2020-08-04	13:55:57
2036	11.02 CM	2020-08-04	13:55:51
2035	11.01 CM	2020-08-04	13:55:45
2034	11.02 CM	2020-08-04	13:55:39
2033	11.02 CM	2020-08-04	13:55:33
2032	11.02 CM	2020-08-04	13:55:28
2031	11.02 CM	2020-08-04	13:55:22
2030	11.01 CM	2020-08-04	13:55:17
2029	11.02 CM	2020-08-04	13:55:11
2028	11.02 CM	2020-08-04	13:55:05
2027	11.02 CM	2020-08-04	13:54:59
2026	11.02 CM	2020-08-04	13:54:54

Fig. 10. Water level monitoring dashboard design

Based on the picture above, the water monitoring IoT prototype has been tested, the results obtained are quite accurate. The data reported on the website-based system are water level in centimeters (cm), date and time of reporting. So the water level will be reported in real time, even though there is a few seconds delay in reporting to the system. In this part of the interface, the system runs well without any problems.

IV. Conclusion

This research has produced a hardware circuit prototype to measure the water level and a rice field prototype. The use of Arduino, ESP8266, and Ultrasonic Sensor to assemble hardware to measure water level is correct. The addition of a plastic bottle as a barrier to moving water or generating waves can increase the accuracy of measuring the water level. However, the choice of material for wave barrier may be replaced with a material that is stronger to withstand waves or water movement, because in the measurement tests there are some inconsistent results. However, from inconsistent results, it can be improved again by using a mathematical filter, such as an average filter with sensor reading delay adjustments. In future research, other types of sensors can be used to measure water levels, for example load cell sensors, lidar, and so on.

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