Smart Water Tanks as a Drought Early Warning System

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Abstract. The availability of water is difficult to measure accurately, causing delays in water supply for the community, so a monitoring tool is needed that can provide accurate and real-time information to measure water availability so that clean water can be distributed to areas that need it on time. The digital indicator developed in this study by adding a water tank system with an ultrasonic sensor HC-SR04 to detect the water level. The working principle of this sensor is that the ECHO pin emits a wave and the TRIG pin is triggered on the reflected wave which is then reflected back so that the obstacle distance can be measured by calculating the time between the emission and the reflected wave. The procedure for installing the sensor on the reservoir is done by installing the sensor on the top side of the tank vertically and there is no media barrier, then water enters with a constant flow rate (m^3/s), and sensor data is recorded by reading the water level (m) which is then converted into unit volume of water (m^3). The Blynk Android application is used as a user interface and monitoring. Water availability monitoring is displayed in a three-color graphic display, green, yellow, and red. Green indicates that the water supply is sufficient (safe level), yellow indicates that the water is insufficient (warning level), red indicates that the water supply is running low or and needs to be refilled immediately to meet the required availability.

Keywords: Drought Disaste · Ultrasonic Sensor · Water Availability Monitor

1 Introduction

Drought is one of the natural disasters that often occurs in various regions of the world and cannot be separated from most parts of Indonesia. This can threaten the survival of the people affected. The biggest cause of drought that hit almost all of Indonesia was a spike in the increase in global temperatures throughout 2016 along with increasing greenhouse gas emissions and the El Nino weather phenomenon. The El Nino phenomenon can affect the time of the dry season. The latest forecast update from BMKG states, that starting October 1, 2018, 68% of areas in Indonesia will be late for the rainy season. At the

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Fig. 1. Graph of Drought Disaster Incidence in Indonesia for 5 Years (Source: [2])

Fig. 2. Community Documentation in Mobile Water Assistance or Water Dropping (Source: [4])

start of the rainy season in the 342 Seasonal Zones (ZOM), 43% is expected to start in November 2018, 22.8% in October at 78 ZOM, and the rest in December 2018. When compared to the 30- year climatological average (period 1981–2010), the start of the 2018/2019 rainy season will generally be backward (68.4%), climatologically normal at 78 ZOM (22.8%), and forward 30 ZOM (8.8%). The rest, 147 ZOM covering parts of Sumatra, Java, Bali, NTB, NTT, Sulawesi, Kalimantan, and Papua will start the rainy season in November 2018 and another 85 ZOM will start in December 2018 [1]. This is reinforced by the surge in areas or cases of areas affected by drought that occurred in Indonesia according to BPS data for 2021 which is presented in Fig. 1.

According to BNPB through a digital information channel [3] it shows that the victims affected by the drought in 2021 amounted to 5,403 victims, different from the previous 2 years which recorded the number of victims affected in 2020 amounting to 1,607,870. victims and in 2019 there were 3,872,358 victims. So that the impact of drought needs to be addressed immediately by utilizing technological developments. The case study presented in this study is in the Special Region of Yogyakarta which is included in one of the areas affected by drought. Meeting the water needs of communities in affected areas during a long dry season only depends on the distribution of water tankers whose arrival is uncertain, this can be seen in Fig. 2. This has an impact on the health of people who need water supplies for their household needs.

The solution to overcome this problem is to optimize effective Drought Management by emphasizing three components, namely monitoring and early warning, risk and impact assessment, and mitigation and response. The availability of water is difficult to measure accurately, causing the water supply for the community to be delayed, so a monitoring tool or technology is needed that can provide accurate and real- time information to measure water availability so that clean water can be distributed to areas that need it on time. The use of this technology is one of the efforts to support drought management that has been realized by this research partner, namely BNPB through Smart TMC Technology (Weather Modification Technology) and Artificial Intelligence for flood and drought disaster mitigation in collaboration with BPPT and BMKG [5].

2 Theoretical Background

The use of water availability monitoring technology to help communities affected by drought to get clean water supply on time is based on efforts to reduce the negative impacts that occur due to drought and become a support step in realizing the achievement of the SDGs (Sustainable Development Goals) targets in goal 6 on Clean Water and Sanitation and the 11 Sustainable Cities and Communities goal and the 13 Climate Change goal. The adoption of this researched and applied technology applies Technology 4.0 with a focus on developing Smart Water Tanks as an Early Warning System for Drought Disasters.

The component that forms the basis for the readings provided by this smart tank technology focuses on monitoring the availability of water by reading the actual water level. In addition, the completeness of the GPS component is also used to facilitate the distribution of clean water supply assistance to areas affected by drought. According to previous research conducted by [6], research on the internet of things-based water level monitoring systems using Google Firebase and carried out using sensors. The sensor used to determine the altitude is an ultrasonic sensor. The data from the ultrasonic sensor is sent to Firebase via a server which can then be monitored via the Android application. The test results show that there is a delay when sending from database to application, from hardware to application and in Idle condition, each produces an average delay of 0.514 seconds, 6.69 seconds, and 0.64 MB per hour. For research that uses water storage media in the form of tanks such as those owned by affected communities, it shows the same thing, namely automatic water tank level control using ultrasonic waves. The sensor used to detect the water level is the ultrasonic sensor HC-SR04 which is installed above the water tank. This study aims to determine the effectiveness of the ultrasonic sensor in detecting the water level. The results show that the sensor is more optimal in detecting the distance between the sensor and the water surface if the water surface is in a state without waves [7]. Then this can be developed and refined through various other components such as monitoring or providing information on the level of turbidity in water tank by designing a turbidity monitoring system and IoT-based water tank cleaning in residents' tanks. This system works when the TSD-10 sensor detects turbidity, the drain pump will open to release water and the cleaning system will be active. The water turbidity data is sent to the firebase by Arduino via SIM 900a and then sent to the cellphone as a notification [8].

So from the various literature, the technology development process developed in this study is in the form of technology that can monitor actual water availability with electronic packaging that is placed with a control system that is easy to operate and has a functional placement.

3 Research Methods

The method used in this research is the product output (prototype) of actual water availability monitoring technology which is carried out in the initial stages, namely designing and analyzing sensor readings by considering existing water tank and being used by the community. Then the design results that have been agreed upon are following the measured analysis utilizing Eqs. 1 and 2 which are continued in the printing process and sensor assembly. Sensor printing utilizes 3D printing technology frequency of approximately 40 kHz is sent from the Ultrasonic transmitter. When a pulse hits an obstruction object, this pulse is reflected and is received back by the Ultrasonic receiver. By measuring the time interval between when a pulse is sent and a reflected pulse is received, the distance between the measuring device and the obstruction object can be calculated. The initial experimental design used was to detect changes in water.

$$\frac{uS}{58} = centimeters \tag{1}$$

$$\frac{us}{148} = inch \tag{2}$$

$$Jarak = \frac{t_{IN}\,sx344\ \text{m/s}}{2} meter \tag{3}$$

$$\begin{array}{l} 148 \\ aa\ = \\ \underline{N}x344/ \end{array} \tag{4}$$

The use of digital manufacturing technology is now very wide and varied. One of the equipments used in digital manufacturing is a 3D Printer. Digital fabrication or often referred to as 3D printer technology will create physical objects from a representative model that has been previously designed [9]. The use of 3D printer technology in such a way that it can represent object models in 3 dimensions makes this technology widely developed for various needs, especially prototyping technology. The next process after the sensor has been made is by attaching the sensor to a test tank with dimensions of 30 and 520 L to try to read the water surface perpendicularly. To calculate the volume of water (m^3) in the tank, water is added continuously with a constant (stable) discharge. The recorded data (water depth) is then converted into water volume (m^3) which is then calibrated with the measured water volume data (m^3) with Eqs. 3 and 4 below.

$$\begin{array}{c} V = \int Adx\ atau \int Ady, \\ dengan\ A\ adalah\ luas\ penamapng\ tanki \end{array} \tag{5}$$

$$V = \pi r^2 \quad (6)$$

$$r = f(x) \text{ or } r = f(y) \quad (7)$$

Level elevation in a small-dimensional tank with a size of 30 L. The procedure for installing the sensor in the tank is carried out by installing the sensor on the top side of the tank perpendicularly and there are no barrier media, then water is entered with a steady discharge (m^3/s), and sensor data is recorded by reading the water level (m) which is then converted into the unit volume of water (m^3). The data is then calibrated with the actual volume shown in the graphic image below.

The sensor used uses an ultrasonic sensor which is used to measure the distance of the obstacle by calculating the time between emission and reflection of the wave. This is done by the TRIG and ECHO pins. The ECHO pin emits waves and the TRIG pin is triggered on the reflected wave, then reflects back. The ultrasonic sensor in this study is also combined with a GPS sensor to assist in knowing the location of the water tank and continue to be developed by adding various sensors according to community needs, especially to follow the Smart Home era in the field of water resources.

4 Results and Discussion

The initial activity used in research on the manufacture of technological products to monitor water availability is carried out by analyzing the amount of variation in tank dimensions to determine the measured volume (m^3) as the basis for calibrating sensor readings. The sensor used is the HC-5R04 sensor whose working principle is to calculate the distance with the HC-SR04 Ultrasonic sensor is to give a pulse (0) when the module starts to operate, when the pulse hits a barrier object, this pulse is reflected, and received back by the Ultrasonic receiver.

Figure 3 shows that the relationship between the measurement results using theoretical analysis and the results from sensor detection shows related results so that the utilization of the water level sensor in the tank is continued on a larger scale. Other results

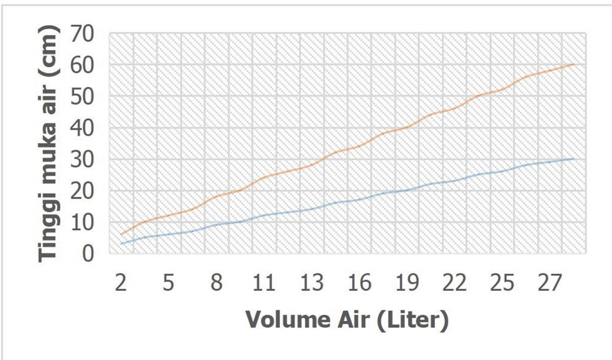

Fig. 3. Amount of Correction/Calibration between Measurement Results and Sensor Detection

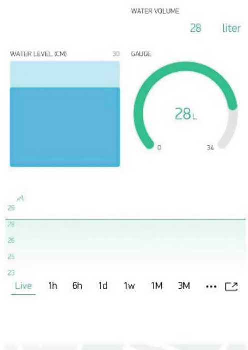

Fig. 4. Sensor Performance Trial by Utilizing a 30 L Water Storage that is integrated with an Information System to Detect Availability of Water in the Tank

obtained during the trial process at the beginning of the study were the division of sensor readings into 3 levels (levels) marked with different light colors and the utilization of a measurable information system by sending data into The Blynk Android application. The level of the water level data shows the condition of the availability of water (m^3) in the tank, which is divided into the first level marked by a green indicator which indicates that the water in the test tank is still sufficient. The second level is marked with a yellow indicator, where the water in the tank is at the threshold. Meanwhile, the last phase, or the third level is marked with a red indicator which shows the water in the tank is on the verge of falling and needs to be filled again immediately to meet the availability of water. The results of readings on the information system are presented in Fig. 4.

The next step for improvement in the manufacture of water availability detection technology is to analyze variations of tanks with capacities of 300 L, 520 L, 650 L, and 1050 L. The equations used are Eqs. 3 and 4 to determine the relationship between the volume of the water tank (m^3) and the change in water level (m) which can be seen from the reading of the elevation of the water tank (m). After obtaining the volume of the tank (m^3) theoretically, then the results obtained from the 4 variations of the dimensions of the tank size above are combined to obtain the formula and characteristics of each water tank quantity.

It is also useful as a basis for making programming languages in the form of coding which is then integrated into the ultrasonic sensor as a measure of the distance of obstacles by considering the time between emission and reflection of waves. The function of the ECHO pin is to emit waves and the TRIG pin is triggered on the reflected wave and then reflects back so that these two pins are used as the basis for making the product in this research. The results of the relationship between water level (m) and water tank volume (m^3) are shown in Fig. 5.

The basis of the calculation is by utilizing dimensional variations and continuing to test the results of the water availability measuring device in the form of a sensor that utilizes 1 tank variation, namely 520 L. The testing of the tool was carried out in the Hydraulics and Environmental Laboratory, Department of Civil Engineering, Vocational School UGM with 5 times of repeated testing and refinement. The process of testing the tool is shown in Fig. 6.

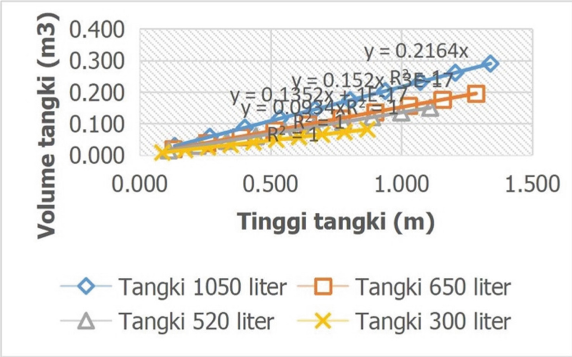

Fig. 5. Graph of Relationship Between Water Level (m) and Water Storage Volume (m^3) on 4 Variation of Tank Dimensions used


A B

C

D

Fig. 6. (A) Laying of Prototype of Water Availability Measurement Sensor, (B) Details of Placement of Integrated Sensor Device on Water Storage, (C) Sensor Test Process, and (D) Readings of Sensor Devices Connected to Information Systems

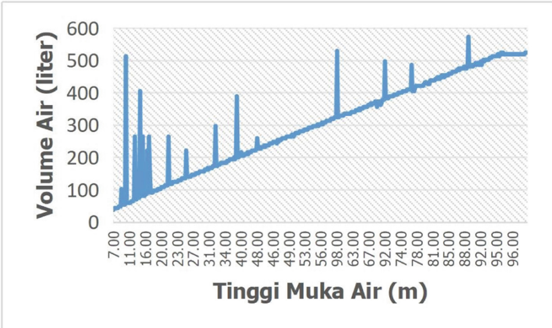

Fig. 7. Sensor Reading Results on Filling Tank Dimensions Size 520 L

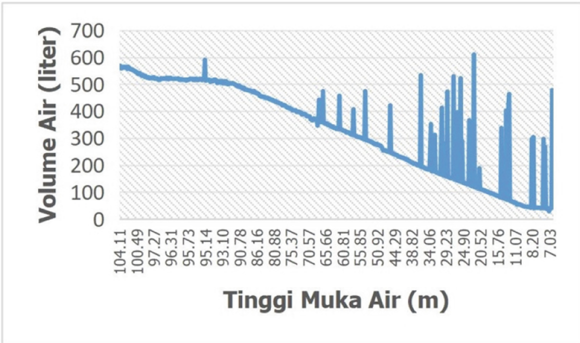

Fig. 8. Sensor Reading Results on Emptying Tank Dimensions Size 520 L

The sensor readings recorded in the storage area are then analyzed for their sensitivity level so they can be adjusted to the actual situation. The presence of wobble due to the water filling process causes the recorded reading data to experience a lot of instability as shown in Fig. 7 and Fig. 8.

As a solution to reduce shocks that affect the data recorded on the sensor device, the device casing will be patented and compact in the water tank used. After knowing the recording of the data obtained, the presentation is given to the community as an effective and innovative form of utilization to be used properly, especially when a drought strikes and requires a clean water supply in a water tank that has been installed with sensors. The microcontroller display on the sensor device is connected to the Android application by displaying colors as an indication of the water level and the location point of the sensor installation that utilizes the Ublox NEO-6M GPS (Fig. 9). The perfection of the sensor equipment is still being developed and refined with various additional sensor readings needed by the community as control of utilization in providing sufficient and healthy clean water.

Fig. 9. (A) Laying of Prototype of Water Availability Measurement Sensor, (B) Details of Placement of Integrated Sensor Device on Water Tank, (C) Sensor Test Process, and (D) Readings of Sensor Devices Connected to Information Systems

5 Conclusion

The development of a sensor tool to read the availability of water in the water tank which was tested on several variations of the dimensions of the water tank in the form of a tub and a tank showed good results. The suitability of readings and data recordings is in accordance with the actual calculation of the existing equations. In the future, components that support sensor devices will be refined by adding reading sensors for water quality parameters. This sensor is the embodiment of Technology 4.0 to assist disaster mitigation activities, especially drought disasters as the Smart Water Tank as an Early Warning System for Drought Disasters.

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