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Development of A Rainwater Harvesting Monitoring System for Agriculture

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ABSTRACT

Rainwater harvesting is simply collecting, storing and purifying the naturally soft and pure rainfall that fall upon the roof. Water resources management play an important part in agriculture development. It is necessary in areas having significant rainfall but lacking in centralized government supply system. It is also suitable to be implemented in areas where good quality fresh surface water or groundwater is lacking. Hence, this project is developed to enable the process of harvesting rainwater for agriculture is been monitored where the data of water collection in tank will be sent to the database for display, storing and analysis purpose. The proposed project will use water level sensor to sense the level of water in the collection tank and the respective valve will response to activate according to the water level. This system also can perform a water treatment and filtration for making sure that the water is clean, and the PH is suitable for agriculture. This project will use Arduino UNO as the controller to control the whole system operation. The information from the sensor is transferred via WI-FI to the database. The result shows that the system is managed to perform the collecting and storing process with sensor error range of +-0.01% for the real reading from the main tank and +-0.1% for the other tank. In addition, the system will allow remote monitoring where the user can trace back the data of the water collection for further water management process.

Key words: Internet of Thing (IoT), rainwater harvesting

1. INTRODUCTION

Rainwater harvesting is the approach of gathering and reserving the rainwater from the roofs when it is raining for later use. This approach has been widely used in several countries like China, Thailand, Australia, United States of America, United Kingdom, Germany, Sri Lanka and India [1]. The technique is relevant in areas with enough rainfall for collection but experiencing water shortage due to either limited availability of conventional water resources, high-water demand or to reduce the water bill. It can also be used in arid regions to overcome water shortage and supply clean water to the plants.

A rainwater harvesting system consists of various stages such as water catchment for the system for receiving the rainfall and transporting rainwater through pipes or drains, filtration, and storage in tanks for reuse or recharge. The basic concept of a rainwater harvesting system is illustrated in Figure 1.

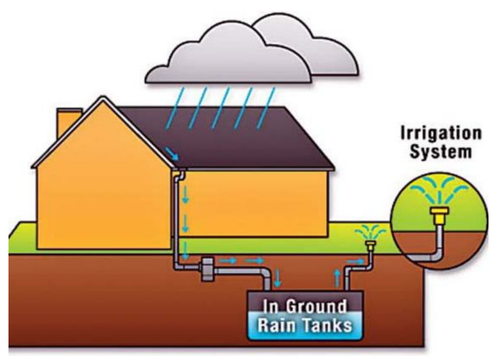

Figure 1: Rainwater Harvesting System

In urban areas, at a household-level, rainwater can be used for flushing toilets, watering gardens and washing the floor and these uses are known as non-potable [1]. As the rainwater harvesting has agricultural uses, it is used to irrigate gardens in the houses and crop plants in-agricultural fields. These decrease the dependence of garden owners and farmers on another sources of water supply during a climate change era where a lot of rainfall cannot be predicted.

In Malaysia, despite rainwater harvesting (RWH) system is still treated as a new practice [2], with the backing and resolution of government in advertising the application of RWH in building, the statistic of building adopting the RWH is increased from time to time. The system has been practised for different type of building like housing, institutional and commercial [3]. Based on International Water and Sanitation Centre (IRC), roughly the cost for RWH is between 2% - 7% from entire construction cost and it is relying on type of the system used. This is a huge investment as to assure the RWH can be used throughout the building lifetime.

However, the traditional rainwater harvesting system is not integrated with any storage and retrieve system or tool to display and monitor the actual operation. This leads the users to be uncertain if the supply water from RWH is enough to be used and water resources management cannot be done properly.

Remote monitoring is a systematic and comprehensive approach that refers to the measurement of any parameters for the disparate devices, and this technology will provide continuous data that will increase the efficiency of any system. Integration of Internet of Thing (IoT) with RWH that being introduced in the proposed system will allow real time remote data transmission between RWH and users. Remote monitoring system benefits to enhance the quality of the current water resources related system with more accessibility in obtaining the RWH's specific parameters.

The remainder of the paper is organized as follows. The system descriptions from hardware until software described in Section 2. The project implementation in Section 3, testing and results are shown in Section 4, and Section 5 concludes this paper.

2. SYSTEM DESCRIPTION

The system can catch rainwater from roof and the rain will flow into the gutter. Then, the water will flow down into the downpipe and will be filtered at the water filter. The filtered water will go into the tank 1 or the main tank for storage. The foreign object cannot go through the water filter and will be washed away by rainfall. As the rainwater can get through the filter, it will flow through the pipe to the water tank. Another two tanks will be used when the irrigation process for the system is running. Tank 2 is for the fertilizer tank and tank 3 is for the auxiliary tank. The tank 3 is used temporary as a mixing tank for water with fertilizer during the irrigation process. Figure 2 shows the conceptual idea of rainwater harvesting system.

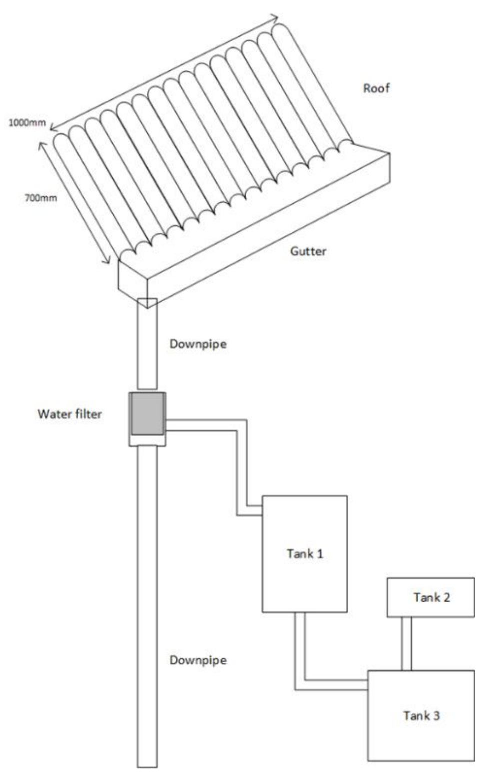

Figure 2: Model of Rainwater Harvesting System

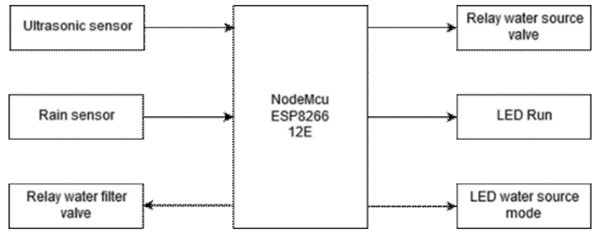

Figure 3: System Architecture Controller 1

The developed RWH model is separated into two system architecture according to their controller types. In the designed system architecture 1 in Figure 3, the system will start by measuring the current water level through ultrasonic sensor in the tank 1. If the water level in the tank is meeting the desired level, the controller will decide to use the water in the tank 1. Vice versa, if the water in the tank is low, then the controller will change to get supply from the tap water. At the same time, the system will wait for the rain sensor to detect the rainfall and make the decision whether to make or break the connection to the relay water source valve based on the available water in the tank. Other than that, it will also send the water level data in the tank to the database through ESP8266 Wi-Fi module built-in the controller itself.

In the system architecture 2 as shown in Figure 4, after the controller is ready, the process of irrigation will start. The controller is integrated with LCD 16x2 to display the status of the system including the fertilizer level. When the irrigation process is started, the controller first will check the fertilizer level in tank 2. In case the level is not enough, the process cannot be continued. If the fertilized water level is enough, the controller will turn on the relay. Valve will active to fill the water in the tank to the desired level. After that, the controller will turn off the relay water valve and turn on the relay fertilizer valve to let the fertilizer flow in until the desired level. The ultrasonic sensor in the tank 3 is constantly measuring the liquid level to make sure the filling water and fertilizer is in desired amount. The water pump will turn on to let the liquid circulate in the tank to mix the water and the fertilizer together for a few seconds. Finally, the pump will stop for a moment to allow the relay process valve to turn on and the pump will start again to irrigate the plants.

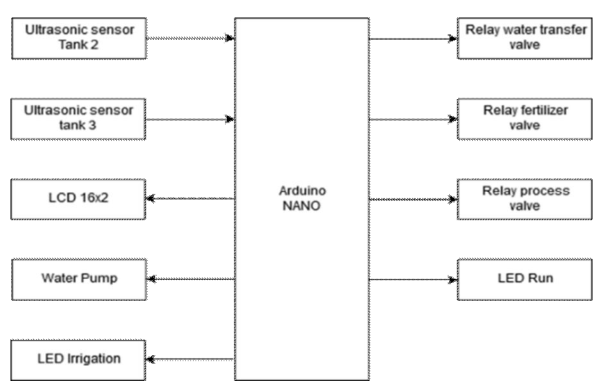

Figure 4: System Architecture Controller 2

A. Ultrasonic Sensor

Ultrasonic sensor is used to detect the water level in the tank by emit sound pulse at regular intervals and they reflected as an echo. It will measure the length to the target depending on the time span between transmit the signal and acquiring the echo.

B. Rain Sensor

Rain sensor can tell when the rain is available and send the signal to the controller. This module can measure moisture through analog output pins and can provides a digital output when a threshold of moisture is exceeded. The lower the resistance (or the more water), the lower the voltage-output. Conversely, the less water, the greater the output voltage on the analog pin. A completely dry board for example will cause the module to output five volts.

C. Arduino Nano

It is a microcontroller board based on the ATmega328P. It has 14 digital input/output pins, 8 analog inputs, a 16 MHz quartz crystal, a USB connection, a power-jack, an ICSP header and a reset button.

D. NodeMcu

The system uses NodeMcu ESP8266 12E as main controller to command the system. The controller will be installed at the Rainwater Harvesting System along with the sensor. The NodeMcu will use a build in WI-FI chip as a gateway between to transmit data from the Rainwater Harvesting system to the cloud.

E. Google Sheet

The gathered data will be tabulated and stored in a spreadsheet in Google Sheet. Google Sheets is an online spreadsheet app that lets users create and format spreadsheets and simultaneously work with other people. For this rainwater harvesting system, the controller will send the real-time data for the rain collected in the main tank or tank 1 to the Google Sheets.

3. SYSTEM IMPLEMENTATION

A. Circuit construction

The project will start with the schematic design of all the components that need to be used in the Rainwater Harvesting system. In Figure 5, the system will use two controller that is NodeMcu ESP8266 12E and Arduino Nano. There are six relay modules, three ultrasonic sensors, one rain sensor, one LCD 16x2 module, six LED lights and two switches used for this system.

After the schematic design completed, the components need to be positioned correctly and soldered to the donut board. There are 2 board used for placing all the components needed. The boards will then be stacked together, and it is divided into upper level and lower level. By referring to the Figure 6, at upper level of the board, there are NodeMcu ESP8266 12E, LED light, LCD 16x2 and connectors. The 4 pins connector is for the ultrasonic sensor and rain sensor. At lower level of the board as shown in Figure 7, there are Arduino Nano, relay module, power switch, power indicator LED and connectors. Each level of the board is equipped with voltage regulator that is used to regulate the voltage to 5V to feed the sensors and the relay module. For the Arduino Nano and NodeMcu ESP8266 12E, the 12V is connected to pin VIN at each of the controller because the controller also has a built-in voltage regulator.

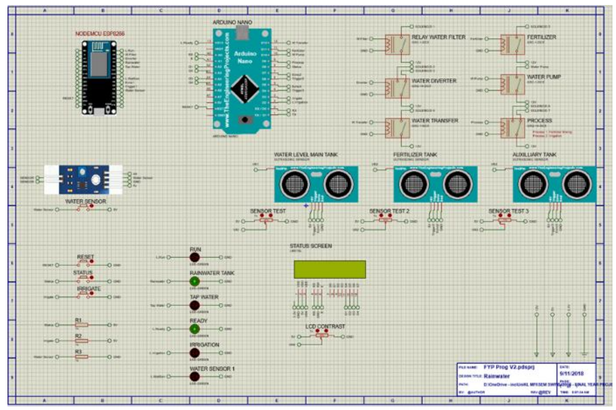

Figure 5: Schematic Design

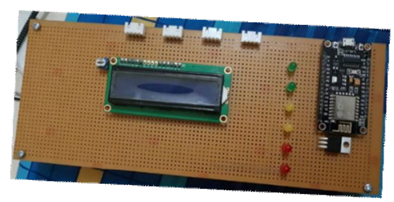

Figure 6: Upper Level Board

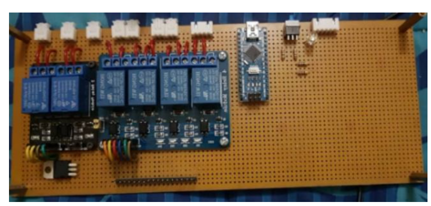

Figure 7: Lower Level Board

B. Water filter design

The shape of the water filter is square with dimension of 72mm length, 120mm wide and 120mm height. The water filter is made of ABS material and it is printed with 3D printer. This water filter will able to filter the water from the leaves that washed away on the roof into the gutter. The leaves that are stuck on top of the filter will be washed away naturally by the running rainwater. There are 2 holes at the side with diameter size of ½ inch and under the water filter with diameter size of 1 inch.

C. Assembly

Figure 8 below shows the constructed structure of RWH. The system is complete with water catchment that is from the gutter, water filter to filter the leaves and three tanks.

Figure 8: Constructed Structure

D. Graphical User Interface development

A simple GUI prototype has been developed by using Wordpress.com to provide the accessibility to the data of specific parameter monitored in RWH. Figure 9 shows the main page of the GUI and system selection.

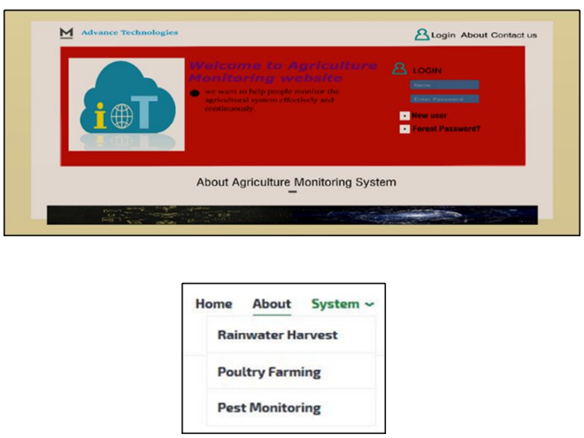

Figure 9: Login Page and System Selection

4. TESTING AND RESULT

A prototype containing all described above has been implemented and tested. Several experiments and tests including both hardware and data submission were carried out during the development stage to verify the function and well-integrated of each component.

A. Functionality Testing

As the LCD notifies that the sensor is ready as in Figure 10, the running water is applied to the gutter continuously. Upon water detection by the rain sensor, the ultrasonic sensors in Tank 1, Tank 2 and Tank 3 fedback accordingly to control the opening and closing of valves in each subsystem. Table 1 shows the description of each LED light that are placed beside the LCD display. Figure 11 shows the different status from the system during testing.

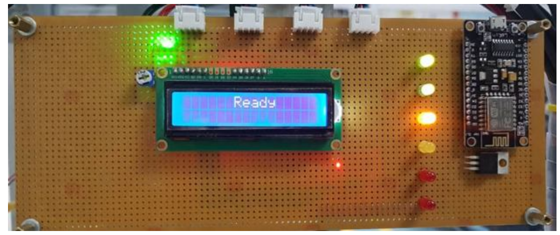

Figure 10: LCD Display

Table 1: Description of LED light

No.	LED	Decription
1		NodeMcu running (Blink)
2		Arduino Nano running (Blink)
3		Alternative water source
4		Main tank water source
5		Rain sensor detect water
6		Irrigation process running

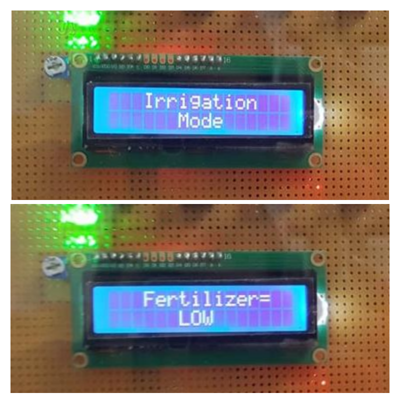

Figure 11: LCD Display on Irrigation and Fertilizer

B. System Performance

The capability of the sensor to sense, collect, store and display variable data are also tested on 30 different condition of water level. Based on the result, it shows that the system is very reliable with error range of +- 0.01% for the real reading from the main tank and +- 1% for the other tank. The system manages to detect the level of the water very well when testing and the connectivity between sensor node and the database is very good without disconnected. Table 2 shows the relationship between the fertilizer level and irrigation process. The irrigation process will only active if the fertilizer level is medium to high. The fertilized water is ready to be irrigated from Tank 3. Figure 12 shows the reading of water level in Tank 1, Tank 2 and Tank 3 at simultaneous time that can be assessed from the GUI developed in WordPress.com.

Table 2: Fertilizer level versus Irrigation Process

Level	Water Level	Irrigation Process
LOW	More than 5cm depth	No
MEDIUM	More than 3cm depth	Yes
HIGH	Less than 3cm depth	Yes

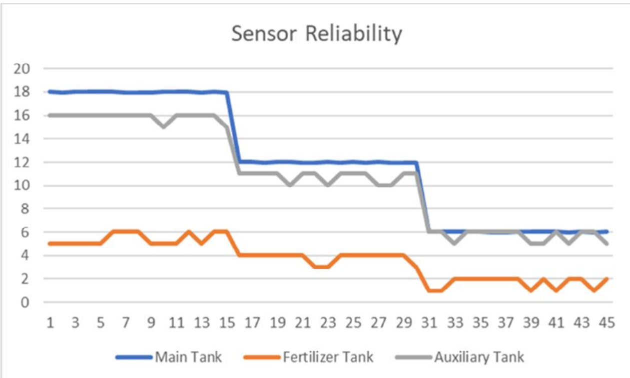

Figure 12: Sensor Reliability Test

The problem faced when completing this project is the connectivity between the sensor data to database. This project is using NodeMcu ESP8266 12E as a Wi-Fi connector between the sensor to the database, but the device needs to be within 10 meter from the Wi-Fi access. If too far the NodeMcu ESP8266 12E cannot find the Wi-Fi and the microcontroller will run normally as it will try to connect the Wi-Fi until successful. As a countermeasure the NodeMcu ESP8266 12E needs to place within 10m meter distance from the Wi-Fi access.

5. CONCLUSION

. The proposed project aims to utilize the rainwater for the useful purpose such as plant irrigation, and to provide the visibility of the system status and performance to the personnel user. With the increasing of monitoring technology such as IoT, indirectly the water resources management can be improved to cater the problem of so much dependency to the standard water resources.

There are some spaces of improvement for this project in the future development. Future development may involve building the treatment tank in addition to the three tanks for the household use. Several analysis and experiments also can be done to observe the efficiency of data transmission, including the location, the distance between two sensor nodes and the capability of the WiFi connection to cope with the system.

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Possible errors of facts and judgement are entirely mine.

REFERENCES

1. Mohammad Thamer, A., Ghazali, A. H., & Megat Johari, M. M. **Empirical Model Simulating Rainwater Harvesting System in Tropical Area,** Universiti Putra Malaysia, Malaysia, 2008.
2. Othman et al. **Policies and incentives for rainwater harvesting in Malaysia,** Kuala Lumpur: Rainwater Utilization Colloquium, 2007.
3. Shaaban, & Huang. **Policies and incentives for rainwater harvesting in Malaysia**, Kuala Lumpur: Rainwater Utilization Colloquium, 2007.
4. Hafsah, B. Y. **Maintenance of Rainwater Harvesting (RWH) in Malaysia**, Kuala Lumpur: University Malaya, 2011.
5. Chin Seong Yeap, & Nasiman Sapari. **Rainwater Quality in Peninsular Malaysia**, 2013.
6. Ir Hj Ismail Abd Rahman. **Rainwater Harvesting System Design,** Malaysia: Cawangan Kejuruteraan Awam dan Struktur Ibu Pejabat JKR Malaysia, 2016.
7. Mohammad Thamer, A., Ghazali, A. H., & Megat Johari, M. M. **Empirical Model Simulating Rainwater Harvesting System in Tropical Area,** Malaysia, Universiti Putra Malaysia, 2008.
8. Shaaban, & Huang. **Policies and incentives for rainwater harvesting in Malaysia**, Kuala Lumpur: Rainwater Utilization Colloquium, 2007.
9. Hwa, N. W. **Reliability and assessment of rainwater harvesting system at the Faculty of Engineering**, PhD Thesis, Faculty of Engineering, Universiti Putra Malaysia, Malaysia, 2009