# *THE DESIGN AND IMPLEMENTATION OF WATER SPINACH CULATIVATION MONITORING BASED ON INTERNET OF THINGS SYSTEMS*

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**Abstract**

Dry season is a condition during which a tropical region experiences a period of rainfall. In several regions in Indonesia, farmers experience crop failure due to the prolonged dry season. The main problem of this is due to the lack of water intake in some plants, especially land spinach (Ipomoea reptans) . This study created an alternative tool to help farmers provide water intake for land spinach (Ipomoea reptans) by creating the design and carrying out the implementation of land spinach cultivation monitoring based on internet of things system. With this alternative tool, farmers can water the plants automatically and manually from a distance.\

In this study, the automatic plant watering tool used a soil moisture sensor with a minimum humidity value of 60\% and a maximum of 100\%. The height measurement used the HC-SR04 sensor (Ultrasonic Sensor) with a value of 15 to 25 cm. The measurement of soil acidity used a soil pH sensor with a normal pH value of 5.5 to 7. Moreover, NodeMcu was employed as a microcontroller. The data obtained by the sensor were processed by NodeMcu and uploaded to Firebase using a Wi-Fi network, then displayed on the website. With this component, the plant watering tool could be operated automatically.\

The results denoted that this tool could automatically water the land spinach (Ipomoea reptans). The measurement data could be viewed on the website in real time. Measurements on land spinach (Ipomoea reptans) were carried out at three different mounds. The tests were done to determine the value of soil quality suitable for land spinach (Ipomoea reptans) fertility. The average yields of soil quality were 90\% humidity, 5.5 for soil pH, and 10 cm for height at mound one; 89\% humidity, 5.7 for soil pH, and 10 cm for height at mound two; and 91\% humidity, 5.6 for soil pH, and a height of 10 cm at mound three.

Keywords: Internet of Things (IoT), Sensor, Soil Fertility, land spinach.

## 1. Introduction

Drought is one of the most frequent disasters caused by extreme climates in Indonesia with different frequencies and levels of risk. In the agricultural sector, the climate is a limiting factor in the process of plant growth and production as well as a very valuable resource and plays an important role in agricultural development. The impact of climate change is not only related to the warming of the earth’s surface temperature, but, more importantly, also related to its impact on food vulnerability [1]. Vegetable commodities are increasingly important. Their high demand is in line with the population growth. One of the most popular vegetable commodities in Indonesia is land spinach. The demand for land spinach continues to increase, in line with the increasing public awareness of the importance of nutrition. Therefore, land spinach cultivation has potential marketing opportunities. In addition to lo- cal markets, land spinach is sold in supermarkets. Cultivating the right vegetable commodity can increase farmers’ incomes [2]. Increased land spinach production certainly requires a lot of attention in cultivation techniques[3], especially in terms of water needs.

Recent developments in the field of information and communication enable the emergence of a new paradigm of intelligent sensor technology that can be widely used to monitor and control aspects of the environment and water needs. Today, the Internet of Things is a crucial transformation of traditional technology. Traditional agriculture is limited by climate change. One of the impacts of climate change is fluctuating rainfall which affects crop productivity. Therefore, a tool to monitor the development of vegetable crops is a technological development that transforms the traditional technology and helps overcome the limitation. Internet of Things (IoT) is a term that recently gains its popularity, but few understand the meaning of this term. In general, the Internet of Things can be interpreted as objects around us that can communicate with each other through the internet network. The Internet of Things (IoT) plays an important role in daily life by controlling electronic devices using networks. Control is done by carefully observing important parameters that produce important information [4].The ability to remotely track and correlate the influence of local environmental conditions on healthy plant growth can have a major impact on increasing the survival rates of plants and increasing agricultural yields[5].

**1.2 Problem Statements**

1. Some areas in Indonesia experience a prolonged dry season which makes farmers experience crop failure.
2. The measurement results are displayed on WhatsApp and smartphone applications.
3. Monitoring of land spinach (Ipomoea reptans) can only be done at the locations where land spinach is planted.

**1.3 Research Objectives**

This study has several objectives and benefits as follows:

1. to offer a solution to create an alternative automatic watering tool using multiple sensor;
2. to display the measurement results on the website in detail and in real-time; and
3. to monitor of land spinach (Ipomoea reptans) anywhere and anytime using this tool.

**1.4 Research Boundaries**

This study has several research boundaries as follows.

1. Internet connection was needed.
2. The maximum range of the HC-SR04 sensor, the soil moisture sensor, and the soil pH sensor were only three meters.
3. The sensor could only display soil quality values but could not determine what were contained in the soil.
4. The trial data were used as reference data in measuring soil moisture.

**1.5 Writing Systematic**

This undergraduate thesis is written in the following order.

a. Chapter 1 INTRODUCTION
This chapter contains background, scope of the study, research objectives, etc.

b. Chapter 2 BASIC CONCEPTS
This chapter contains an explanation of the basic theory, website, and tools.

c. Chapter 3 SYSTEM DESIGN
This chapter contains the flowchart, algorithm, experimental diagram and the methods.

d. Chapter 4 RESULT AND ANALYSIS
This chapter contains research procedurs, test conducted, result of the tests, and analysis of the results of the tests.

e. Chapter 5 CONCLUSION AND SUGGESTIONS
This chapter contains the conclusion and suggestions of this undergraduate thesis.

**2. Basic Concepts**

**2.1 Internet of Things**

Internet of Things is a global infrastructure for the data society, enabling advanced services by connecting things based on existing and evolving interoperable information and communication technologies. The internet of things can be thought of as a broad vision with technological and social implications. From a technical standardization perspective, Internet of Things is seen as a global infrastructure for the data society, enabling advanced services by connecting things based on existing and evolving information and communication technologies. Internet of Thing is expected to significantly integrate leading technologies, such as technologies related to advanced machine-to-machine communications, autonomous networking, data processing and decision making, security and privacy protection, and cloud computing, with technologies for advanced sensing and actuation [6].

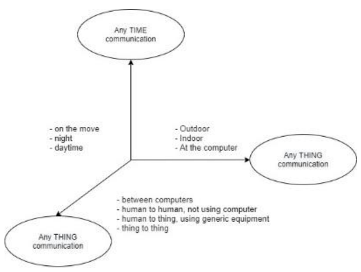

**Fig. 1 – The New Dimension of IoT [b-ITU Report].**

### 2.2 Land Spinach (Ipomoea reptans)

The content of Land spinach (Ipomoea reptans) is flavonoids, polyphenols, vita- min E and has a very high antioxidant activity compared to Centella Asiatica, Nyctanthes arbortristis, etc [7]. According to [8], the benefits of land spinach are the same as vegetables in general, spinach contains high fiber. One hun- dred grams of Land spinach (Ipomoea reptans) contains 458 grams of potassium and 49 grams of sodium. Both of these substances are compounds of bromide salts that work as a sleeping pill because of its suppression of the central nervous system. Kale contains sedatives that can reduce tension and induce calm.

### 1. Device/Sensors

Sensors are the differentiator that makes IoT unique from other advanced machines. Sensors are capable of defining instruments, which transform the Internet of Things from a standard network and tends to be passive in devices, to an active system that can be integrated into the real world [9].

- **Soil Moisture Sensor**

  Soil moisture sensor FC-28 is a humidity sensor that can detect moisture in the soil. The soil moisture sensor is a sensor that can detect the intensity of water in the soil (moisture).

- **Ground pH Sensor**

  Soil pH is the acidity or basicity of an object being measured with a pH scale between 0 to 14. An instrument for detecting pH is called a pH sensor.

- HC-SR04 Sensor (Ultrasonic sensor)

  HC-SR04 sensor is an ultrasonic sensor that can be used to measure the distance between an obstacle and the sensor.

- NodeMCU

  NodeMCU is an open-source firmware and development kit that helps to build IoT product. NodeMCU is developed to make easier using advanced API for hardware IO.

- Integrated Circuit (IC) Step down

  IC LM2596 is an integrated circuit that functions as a step-down DC converter with a current rating of 3A. Step down IC used is an IC circuit whose output voltage can be varied [9].

- Relay

  Relay is an electronic component in the form of an electronic switch that is driven by electric current. In principle, the relay is a switch lever with a coil of wire on a nearby iron rod (solenoid).

- Water Pump

  A water pump is a device used to move a liquid from one place to another by increasing the pressure of the liquid.

### 2. Connectivity

Connectivity is the connection between all points in the IoT ecosystem, such as sensors, gateways, routers, applications, platforms, and other systems.

### 3. System Design

### 3.1 System Method of Sensor

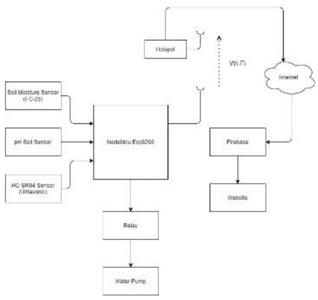


**Fig. 2 – Overall System Block Diagram.**

The realized system is part of the tools and applications. Soil moisture sensor, soil pH sensor, and HC-SR04 sensor are used for the sensor subsystem. The Internet of Things Device subsystem used is NodeMCU. For the gateway subsystem, this tool uses the Wi-Fi gateway of the mobile device's hotspot network. The Internet of Things Platform/Cloud subsystem used is firebase.

**3.2 Flowchart of Sensor**

Create a flowchart to explain how the tool works in a structured manner. When the system is turned on, the NodeMCU and the sensors used will start working. The Soil moisture sensor will measure soil moisture, the soil pH sensor will measure the acidity and alkalinity of the soil, and the HCSR04 sensor measures the height of the land spinach (Ipomoea reptans) and sends it to the NodeMCU.

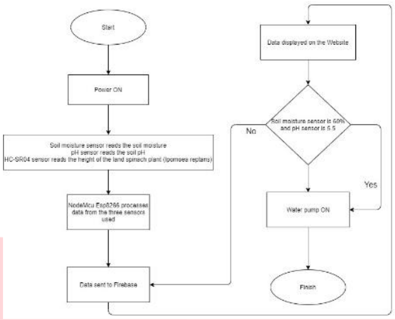


**Fig. 2 – Flowchart of Sensor.**

**3.3 System Method of Connectivity**

Sets up the wifi connection used so that NodeMCU gets a link to connect to the internet. To determine the WIFI SSID, fill in the username for the name of the wifi device used, and for WIFI PASSWORD, enter the password according to the device used. That way, NodeMCU will automatically connect to the internet network.

**3.4 NodeMCU Configuration With Sensor**

NodeMCU configuration with sensors is also done so that data from each sensor can be processed, then uploaded to the Firebase database and displayed on the Website.

**4. Result and Analysis**

**4.1 Realization**

The realization that made is the result of the previously designed system concept. What has realized consists of 2 parts, including Sensor, and Connectivity.

**4.1.1 Realization of Sensor**

The realization of this sensor aims to show that the sensor has been designed in such a way that it can measure soil moisture, soil pH, and plant height of land spinach (Ipomoea reptans).

**4.1.2 Realization of Connectivity**

The connectivity used is a Wi-Fi network that comes from a smartphone hotspot, then connects to NodeMCU and sends data to Firebase which then displays it on the Website. By setting the network name in the Arduino IDE program, NodeMCU will automatically work with the network.

**4.2 Testing Result**

In this section, several tests were carried out, including testing the accuracy of measuring soil moisture, soil pH, the height of land spinach (Ipomoea reptans) plants, and testing the speed of data transmission.

**4.2.1 Hardware Testing**

In this test, the observed output is the success of the tool in carryingout each task. Starting from the NodeMCU, Soil Moisture Sensor, Soil pH sensor, and the HC-SR04 sensor. From the results of hardware testing, the different results for each sensor and digital sensor, where the different results obtained are not too far away, the sensor tools used are soil analyzer and ruler while for digital sensors used are Soil moisture sensor, Soil pH sensors, and HC-SR04 sensors.

**4.2.2 Tool Range Testing**

This test is carried out to determine the maximum range between the microcontroller (dry part) and the connected access point, the test is carried out by running the tool and changing the distance of the access point with the microcontroller. Testing is carried out directly in the garden.

**4.2.3 Quality of Service**

The ability of a network to provide adequate services by providing bandwidth, jitter, and delay. Quality of Service is a measurement method used to determine the capabilities of a network such as; network applications, hosts, or routers with the aim of providing better and planned network services so that they can meet the needs of a service. In this final project, the Quality of Service parameters tested are delay and throughput.

**4.2.4 Delay**

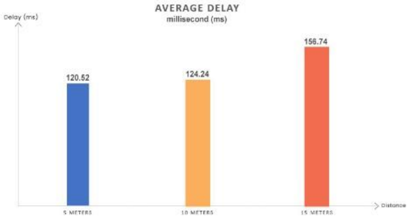


**Fig. 3 – Average Delay.**

From the experimental results above, the results of the delay are for a distance of 5 meters, the average obtained from 5 trials the results are 120.52 ms or 0.12052 s, then for a distance of 10 meters the results are 124.24 ms or 0.12424 s, and for a distance of 15 meters get the result that is 156.74 ms or 0.15674 s.

**4.2.5 Throughput**

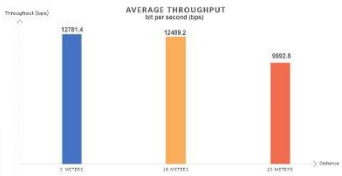


**Fig. 4 – Average Throughput.**

The overall average throughput at each distance of the tool range. From the graphic above, it can be seen that the average throughput value is greatest at a distance of 5 meters with an average value obtained of 12781.4 bps, while the average value of the smallest throughput is at a distance of 15 meters with an average value of 12781.4 bps. Obtained at 9992.8 bps.

**5. Conclusion**

Based on the results of testing, measurement, and analysis, the following conclusions are obtained:

1. The Internet of Things (IoT)-based watering device for land spinach (Ipomoea reptans) as a whole is designed to consist of NodeMCU ESP8266, a soil moisture sensor to determine the humidity in land spinach plants (Ipomoea reptans), a soil pH sensor to determine the required pH value. on the ground, sensor HC-SR04 to determine the height of the land spinach (Ipomoea reptans), relay to regulate the power on and off on the water pump, water pump to maintain the condition of land spinach (Ipomoea reptans) not out of the ideal range, dry battery 12V is used for the power supply, the Stepdown IC to lower the battery voltage, the switch for connecting and disconnecting the circuit manually, and Firebase to display the quality data of land spinach (Ipomoea reptans) in real-time.
2. In testing the performance of the tool, it can be concluded that the tool is able to reach the network from the access point up to 15 meters with very good quality. The following are the conclusions from the results of the Quality of Service (QoS) measurement:
   a. The Firebase database is able to display the results of reading land spinach (Ipomoea reptans) from the sensor correctly and the best average delay value is 120.52 ms at a distance of 5 meters, while the largest average delay is obtained at a distance of 15 meters with a value of 156.74 ms.
   b. The best throughput value is at a distance of 5 meters with an average value of 12781.4 bps, while the most at a distance of 15 meters with an average value of 9992.8 bps.

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