# Mobile App for Plant Watering System with Verticulture Planting Technique

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**Abstract.** The conversion of agricultural land into residential areas has resulted in a decrease in the availability of agricultural land, so it is necessary to implement an intensive agricultural pattern with a high level of productivity. One of them is by applying a vertical farming pattern or known as verticulture. The technique of planting verticulture is an agricultural cultivation system solution that can be applied in densely populated areas because it does not require large areas of land. Driven by technological developments in the current era, verticulture no longer use conventional methods. Automation processes using microcontrollers have been widely used in this field with the aim of monitoring, controlling and predicting. The purpose of this research is to build a mobile application on a watering system with vertical planting techniques. This research begins with designing a system using Arduino Uno, Soil Moisture Sensor, SD Card Module, and ESP-01. After that, calibrate the sensor and sensor sensitivity using relative frequencies. Then analyze the stored soil moisture data using a boxplot, pearson correlation, and wilcoxon test then integrate the data in a mobile web application. The research results show that the soil moisture of each sensor has a different pattern and average. The sensor can detect soil moisture in dry and wet conditions well so that it can automatically water plant.

**Keywords:** Mobile App · Plant Watering System · Soil Moisture · Arduino

## 1 Introduction

The population of Indonesia is increasing very rapidly every year, so the area of land that is available and can be processed for agricultural areas is also increasingly limited. The conversion of agricultural land into residential areas has resulted in a decrease in the availability of agricultural land. Improvement efforts are needed by applying an intensive farming pattern with a high level of productivity, one of which is by applying a vertical farming pattern. The vertical farming pattern or known as verticulture is a solution to the agricultural cultivation system that can be applied in densely populated areas because it does not require large areas of land. Some of the advantages of vertical farming are efficient in land use, easy to maintain, save on the use of fertilizers and biopesticides, practical, easy to control weeds, can be moved easily and harvested vegetable crops are cleaner and healthier [1].


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Maintaining the availability of water in the summer season is very important to do, especially during the period of growing roots and branches (vegetative). Watering plants should be done up to 3–4 days. Lack of water in the vegetative period can cause plants to be lazy to germinate and wilt. To obtain optimal plant growth, watering must be done regularly so that throughout the plant life cycle, water needs can be met, especially during the summer season [2]. One effort to provide water to plants on a regular basis is to use an automatic watering system. Automatic watering devices can detect soil moisture using sensors and Arduino. The program on Arduino then detects soil moisture at a certain time and then automatically pumps water [3].

Mobile technology plays an important role in our activities and interactions in today's daily life. The use of mobile applications has been used massively to various sectors in recent years, such as health, education, industry, and agriculture [4]. One example of the use of mobile applications in agriculture is to carry out the monitoring process. Environmental monitoring process can increase the efficient crop yields Monitoring of environmental conditions is formed through the development of a program system through an android application that detects soil moisture [5].

Previous research that applied technology with verticulture planting techniques were [6, 7]. The results of this research are a prototype product applied in verticulture (hydroponic). The prototype is able to control pumps via smartphones. So that, monitoring and control of plant systems can be done remotely via a mobile app.

Utilization of automatic plant watering systems with vertical techniques can be done using a parallel automatic watering system installation scheme which is then integrated into a mobile application. This parallel automatic system installation uses Arduino, soil moisture sensors as inputs and water pumps as outputs which are integrated with each other. The automatic watering system in parallel will consider the frequency and length of watering time. Therefore, it is necessary to adjust / configure the frequency and duration of watering on the automatic plant watering system in order to accurately and consistently maintain the quality of soil.

## 2 Material and Methods

### 2.1 Verticulture Planting Techniques

Verticulture is a method of farming by placing the planting media vertically (tiered). Gardening the vertical way knows no seasons and does not require complicated techniques, so all levels of society can do it. This method is appropriate for narrow or residential areas. The advantages of this vertical system are many, such as saving land, not needing expensive costs, higher productivity. When applied to the onion, the bulbs produced are small but the taste is more spicy [8].

### 2.2 Arduino

Arduino is an open-source microcontroller that can be configured using the C programming language and is updated regularly. Arduino is well-equipped with libraries tools, making it easy to use for who are not pre-planned in the microcontroller. In 2005, Arduino was originally designed to develop tools that can interact with sensors.

Arduino microcontrollers can receive and respond to information through input and output devices in various forms. One of them is sending and receiving information over the internet (HTTP requests). In order to connect to the internet, Arduino requires an ESP board as a supporting device. The ESP board can act as a Wi-Fi server or arduino connecting device with an internet access point [9].

### 2.3 Wilcoxon Signed-Rank Test

In carrying out a statistical test, several assumptions need to be fulfilled, one of which is that the data must follow a certain distribution. If this is not met, then one solution is to perform a non-parametric test. One of the non-parametric tests is the Wilcoxon Signed-Rank Test or Wilcoxon Test.

**Hypothesis:** $H_0$: $m = m_0$

$H_1$: $m \neq m_0$
Test Statistics:

$$W = \sum_{i=1}^{n} Z_i R_i \tag{1}$$

where $R_i$ is the rank for $i = 1, 2, \ldots$, n. $Z_i$ is an indicator variable for $X_i - m_0$ is negative or positive value (0/1)

Test Criteria:
$H_0$ Rejected if $W > Z_{(table)}$ or p-value <0.05 [10].

### 2.4 Pearson Correlation Test

Pearson Correlation or Pearson Product Moment Correlation is a subset of linear correlations. Pearson correlation is used to check for linear correlation between two variables. The steps for conducting a personal correlation test are as follows. The steps for conducting the person correlation test are as follows:

**Hypothesis:** $H_0$: $\rho = 0$

$H_1$: $\rho \neq 0$
Test Statistics:

$$\rho = \frac{COV(X, Y)}{\sigma_X \sigma_Y} \tag{2}$$

where $COV(X, Y)$ is covariance of the X and Y variable. $\sigma_X$ and $\sigma_Y$ is the standar deviation of the X and Y variable.

Test Criteria:
$H_0$ Rejected if p-value <0.05 [11].

### 2.5 Data Analysis Method

**Make Vertical Planting Media.** Vertical planting media is is built using pipe media.

**Set Up An Automatic Watering System Using Arduino.** The system was set up using Arduino, soil moisture sensor, mini board, SD Card Module and Water Pump.

**Analyze Soil Moisture Data.** Data analysis was performed using the Wilcoxon Test and the Pearson Correlation Test. The Wilcoxon Test was used to see the pattern of watering frequency, while the Pearson Correlation Test was used to see the pattern of watering time. Data analysis was performed using R software package [12].

**Build a Plant Watering Mobile App.** Mobile app built using Blynk Cloud Platform.

## 3 Material and Methods

### 3.1 Automatic Plant Watering System

Watering system set up automated using Arduino Uno. The system wields a soil moisture sensor as an input to determine the watering time. The soil moisture sensor produces a value over a certain range. In order to make it easier for interpretation, it is necessary to calibrate the soil moisture value from sensor in different planting media.

Figure 1 shows the calibration process of the soil moisture sensor. The calibration result shows that the soil moisture rate is in the range of 200 – 600. Based on this information, the soil moisture rate is converted into a percentage (0–100). The greater the percentage, the wetter the soil is. After performing the calibration, a plant watering system was arranged using Arduino Uno.

Figure 2 shows the design and implementation of an automatic plant watering system. The planting watering system was built using Arduino Uno, soil moisture sensor, mini

(a) (b)

**Fig. 1.** Illustration of sensor calibration on (a) soil and (b) water planting media

(a) (b)

**Fig. 2.** Automatic Watering System Arduino Uno (a) Inside and (b) Outside View

board, SD Card Module and Water Pump. The soil moisture sensor is positioned in the pipe gap that has been provided just below the plant being planted so that it can be protected and detects soil moisture in the planting area properly.

### 3.2 Soil Moisture Data Analysis

The plant watering system was then installed on the vertical planting medium and soil moisture was observed. Observation of soil moisture was carried out for 3.5 h. The stored soil moisture data was then analyzed using boxplot. The analysis was then continued using Wilcoxon Test and Pearson Correlation Test.

Figure 3 shows that the most extreme difference in soil moisture values is found in sensor 1. Box plot Sensors 2, 3 and 4 seem to show no difference in soil moisture values. Another thing to note is that there are outlier data on sensors 3 and 4. To determine the difference in soil moisture values, the Wilcoxon Test was carried out. The results of the Wilcoxon Test are given in Table 2.

Table 1 shows that each sensor has a p-value $<0.05$. This shows that there are differences in the value of the soil moisture data center for all sensors. The difference in

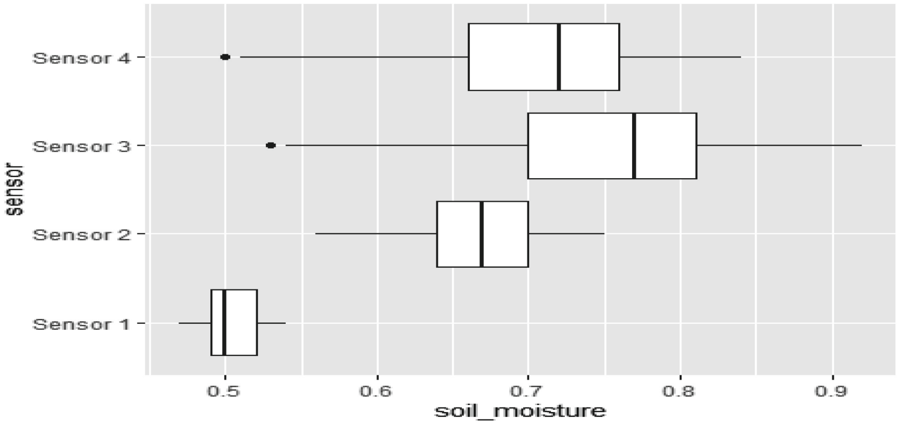


**Fig. 3.** Boxplot of Soil Moisture Data

**Table 1.** Wilcoxon Test Results

| Sensor | W | p-value |
|---|---|---|
| 1 & 2 | 156400036 | $2.2 \times 10^{-16}$ |
| 1 & 3 | 3113 | $2.2 \times 10^{-16}$ |
| 1 & 4 | 53405 | $2.2 \times 10^{-16}$ |
| 2 & 3 | 125399933 | $2.2 \times 10^{-16}$ |
| 2 & 4 | 43539496 | $2.2 \times 10^{-16}$ |
| 3 & 4 | 104628370 | $2.2 \times 10^{-16}$ |

**Table 2.** Pearson Correlation Test Results

| Sensor | Correlation | Statistics | p-value |
|---|---|---|---|
| 1 & 2 | 0.82 | 161.71 | 2.2 x $10^{-16}$ |
| 1 & 3 | 0.75 | 128.97 | 2.2 x $10^{-16}$ |
| 1 & 4 | 0.66 | 99.366 | 2.2 x $10^{-16}$ |
| 2 & 3 | 0.94 | 316.83 | 2.2 x $10^{-16}$ |
| 2 & 4 | 0.69 | 316.83, | 2.2 x $10^{-16}$ |
| 3 & 4 | 0.70 | 316.83 | 2.2 x $10^{-16}$ |

values indicates that the frequency pattern of watering the plants carried out needs to be distinguished for each plant on vertical planting media. This difference can be realized in programming by setting a limit on the value of soil moisture needed to water plants.

After knowing the difference in the value of soil moisture in each sensor, the analysis was then continued to determine the relationship between the value of soil moisture in each sensor. To find out how strong the linear pattern formed on each sensor is, it is necessary to analyse the correlation value.

Table 2 shows that each sensor has a p-value $<0.05$. This shows that the soil moisture sensor values are interrelated. If it is associated with the case of watering plants, the result of the vertical shape of the vertical media will make water flow through the entire plant. So that, the value of soil moisture in one plant can be affected by water seepage in the plants above it. This linear relationship shows that the pattern of watering time for plants needs to be distinguished for each plant.

### 3.3 Plant Watering System Mobile App

Based on the analyzed results, it is known that it is necessary to make a difference in the frequency of watering patterns and the length of time of watering. Therefore, it is necessary to build a flow chart of the plant watering process. The flow chart for the plant watering system is as follows:

Based on Fig. 4, the sensor can detect soil moisture in dry and wet conditions well so that it can automatically water plant. The next step is uploading the programming code that connects to to the blynk cloud platform. The program code is as follows.

if the programming code in Fig. 5 successfully connects with the blynk app, there will be 4 sensor outputs on the blynk application dashboard display. The output is then displayed using the available widget. The display on the mobile application is as follows.

The mobile application displays the soil moisture sensor percentage value for each sensor. There is also a button that functions to run the plant watering system (see Fig. 6). Because it is applied to verticulture, different output results are obtained for each plant.

Plant watering can be arranged remotely by the mobile app. Because it is applied to verticulture planting techniques, this application allows the duration and frequency of watering to be different for each plant. So that, the application has the potential for development to prevent excessive water use and improve the quality of plant growth.

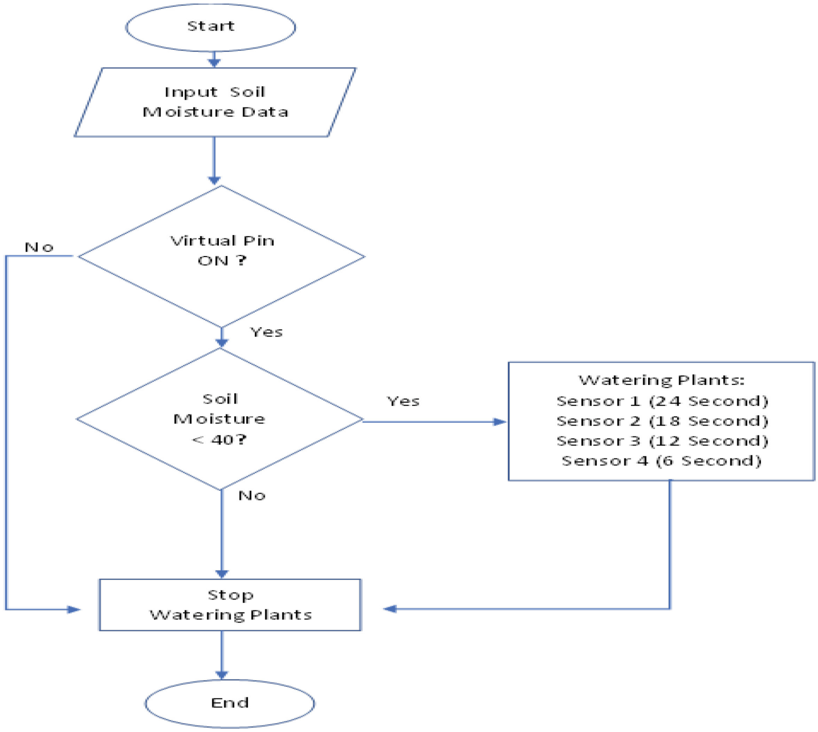


**Fig. 4.** Flow Chart of Mobile Application Plant Watering System Algorithm

```
void setup()
{EspSerial.begin(ESP8266_BAUD);
 Blynk.begin(auth, wifi, ssid, pass, "blynk.cloud", 80);}
void loop()
{Blynk.run();}
```

**Fig. 5.** Program code that connects to the blynk application

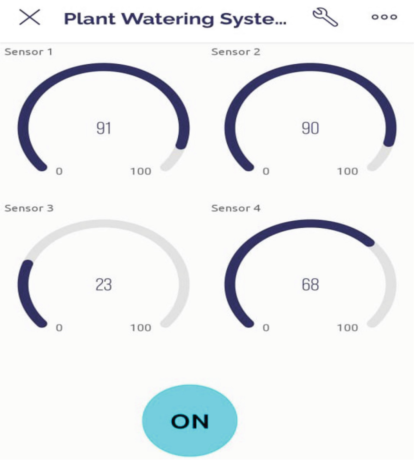


**Fig. 6.** View of Plant Watering System Mobile App

## 4 Conclusion

This research shows that the soil moisture value in each sensor has different patterns and average so that different patterns of frequency and duration of watering are needed for each plant. The sensor can detect soil moisture when it is dry and wet well, so it can water plants automatically.

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