ISSN. 1412-4785; e-ISSN. 2252-620X, Accredited by Kemendikbudristekdikti No. 105/E/KPT/2022
DOI: 10.17529/jre.v20i2.35120

# Pre-Symptom Detector of Root Disease Palm Oil (Ganoderma) Trunk Based on LoRa and IoT

Ferry Hadary[1]*, Ochih Saziati[2], and Ahmad Dzakiyuddin Muhaimin[1]
[1]Department of Electrical Engineering, Universitas Tanjungpura
[2]Department of Environmental Engineering, Universitas Tanjungpura
Jl. Prof. Dr. Hadari Nawawi, Kota Pontianak 78124
*e-mail: ferry.hadary@invent.untan.ac.id

*Abstract*—**The stem rot disease caused by Ganoderma boninense is a type of disease that is deadly to oil palm plants and can cause a significant reduction in oil palm productivity. Difficulty in detecting disease-infected oil palm plants is the cause of the high risk of plant death due to the condition and risk of oil palm plants being affected by disease as early as possible. The system used is Long Range (LoRa) technology which utilizes radio frequencies as signal transmission between transmitter and receiver devices. The transmitter device is equipped with TGS 2611, MQ-138, MS1100, and TGS822 sensors as a tool for detecting Ganoderma disease and is also equipped with a GPS sensor which functions to map trees affected by the disease. Meanwhile, the receiver as the recipient of the data that has been sent by the transmitter via LoRa will be forwarded to BIynk Apps via the internet network, thus forming an internet of things system. This technology helps monitor oil palm plantations more efficiently because it can be monitored in real-time on a smartphone application. The research results show that the four sensors can detect levels of Volatile Organic Compounds (VOC) from Ganoderma fungi with three classifications; healthy, moderate, and sick.**

***Keywords: ganoderma, palm oil, long range (LoRa), internet of things***

## I. Introduction

Kalimantan Barat is one of the provinces with the largest oil palm plantations in Indonesia. Based on data from the central statistics agency in 2020, Kalimantan Barat was able to produce 5.742,925 tons of oil palm plantation products with a planting area of 2.109,890 Ha. The abundant plantation products in Kalimantan Barat are not in line with the plantation productivity of palm oil. It is known that oil palm productivity is still below average, namely 3.282 Kg/Ha from the national average of 3.339 Kg/Ha [1].

Disease is one of the factors that affects the productivity of oil palm plants. Root stem rot disease (*Ganoderma*) is a type of disease that often and most damages oil palm plants and the cause is the *Ganoderma boninense* [2]. The plant death rate due to *ganoderma disease* which reaches 80% causes as significant reduction in oil palm productivity of up to 50% per hectare area, with potential losses estimated at more than USD 250 million [3].

Difficulty in detecting oil palm plants attacked by stem rot disease is one of the causes of the high risk of death. Oil palm plants are affected by stem rot disease. It is often handled and treated too late, thereby reducing the productivity of plantation products. Therefore, detection technology is needed that can determine as early as possible the condition and risk of oil palm plants being affected by disease. Apart from helping in making decisions on the timing and targets for pesticide use, it also helps in the process of monitoring oil palm plantations to make it more efficient because it can be monitored in real-time on a smartphone application. The system uses Long Range (LoRa) technology which utilizes radio frequencies as signal transmission between transmitter and receiver devices. On the transmitter there are sensors for early detection of *Ganoderma* disease as well as GPS sensors for mapping trees affected by the disease, while the receiver is the recipient of data that has been sent by the transmitter via LoRa (Long Range) and will be forwarded to Blynk Apps via the internet network, thus forming and IoT (Internet of Things).

## II. Literature Review

### A. Stem Rot Disease

Stem rot disease caused by the Ganoderma boninense is a major problem in oil palm cultivation. Ganoderma boninense belongs to the Basiodiomycetes class and is characterized by spreading from tree to tree through roots and spores. Treatment of stem rot disease is often delayed because the initial symptoms are difficult to detect with the naked eye. During the development process, the Ganoderma boninense is active emits volatile organic compounds (VOC). The three identified VOC produced by Ganoderma include; 2-Furan-carboxaldehyde, 5-(hydroxylmethyl)-, Thiophene, 2-propyl- dan 4H-Pyran-4-one [4]. Previous research related to ganoderma disease

*Received 17 November 2023; Revised 17 December 2023; Accepted 11 January 2024*

detection sensors includes the first on the use of various e-nose sensors to detect ganoderma disease in oil palm plants. The results showed that there was an increase that occurred when testing the sensor on samples of diseased plants due to ganoderma. There are differences in the increase in samples depending on the severity of the disease in the sample and the specifications of each sensor. Therefore, this study used 4 different sensors, but within the VOC gas detection range to see the characteristics of each sensor in detecting ganoderma disease and with the aim of increasing the sensitivity of the system in detecting disease. In this study, it was found that the TGS 822 sensor obtained good readings of root, stem and leaf samples of oil palm plants [5]. The second research on analyzing the sensitivity of several TGS sensors in the e-nose sensor for the identification of ganoderma in the roots of oil palm in 2022, concluded that the TGS2611 sensor is the sensor that has the best sensitivity among several sensors tested [6]. The third research is about using an e-nose sensor in the Volatile Organic Compounds Chamber. Where the MQ-138 sensor used can respond to VOCs gas in the form of Aldehyde, benzene, alcohol and others. Therefore, based on several previous studies on sensors for VOC detection, in this study TGS2611, TGS822, MQ-138 sensors and MS1100 sensors are used which can detect formaldehyde gas (Aldehyde), benzene and other compounds included in compounds found in ganoderma disease as an e-nose system for detecting ganoderma disease [7].

### B. Arduino Uno

Arduino Uno is a type of Arduino microcontroller board that has an Atmega328P based chip. This microcontroller is open source so it is suitable for use in tool design study. The Arduino Uno has 14 digital input/output (I/O) pins (6 of which can provide PWM output), 6 analog input pin, 16 MHz quartz crystal, USB connection, power jack, ICSP header and reset button. Arduino Uno uses a USB type A to USB type B cable to connect to a laptop or computer, as well as voltage source. A DC Voltage source can also be added from outside by inserting it into the power jack. Arduino Uno uses the basic C or C++ programming language with a typical Arduino library that has been developed. Arduino uno is shown in Figure 1.

### C. ESP32 Dev Kit

ESP32 Dev Kit is a firmware that uses the ESP32 module to program with the same LUA script as Arduino and supports the Wi-Fi connectivity feature that is embedded in the board, making it easier to program IoT based projects. This module is the successor to the ESP8266 which has a GPIO (General Purpose Input Output) with 36 pins which function as analog and digital input and output pins. The similarity of the ESP32 Dev Kit program with Arduino means that this module can be programmed via the Arduino IDE application with several additional settings. ESP32 Dev Kit is shown in Figure 2.

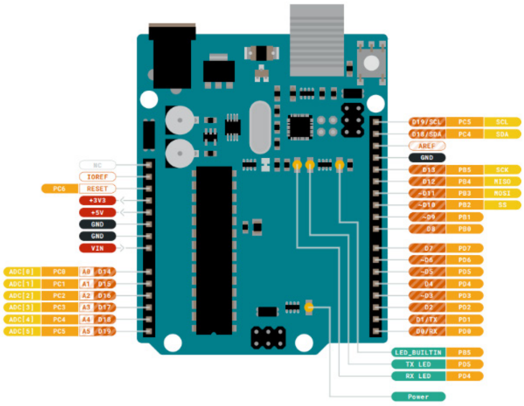


Figure 1. Pinout Arduino Uno [8]

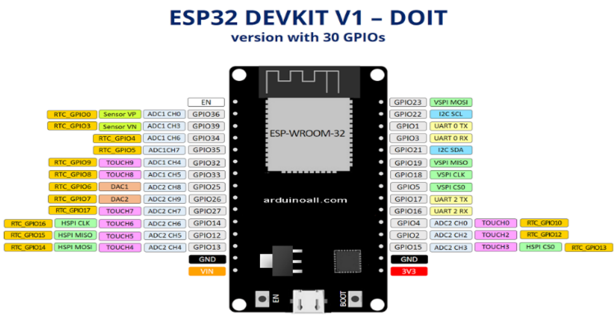



Figure 2. Pinout ESP32 Dev Kit [9]

### D. LoRa RFM95

LoRa RFM95 is LoRa (Long Range) telecommunications module based on radio communication modulation techniques for certain wireless spectrum which has the characteristics of a transmit power that can cover a relatively wide area, with low power consumption. LoRa is a low power wide area network (LPWAN) technology which has a working frequency of 169 MHz, 433 MHz, 868/915 MHz and 2.4 GHz, where these frequencies are unlicensed frequencies that can be used freely. This modulation is determined by three parameters including; bandwidth, spreading factors (SF) ranging from 6 to 12 and the coding rate (CR) parameter which determines the value of the FEC code. LoRa RFM95 is shown in Figure 3.

### E. TGS 2611 Sensor

The TGS 2611 sensor is a sensor that has the ability to measure levels of methane gas or other natural gas, with high sensitivity, low power consumption and good

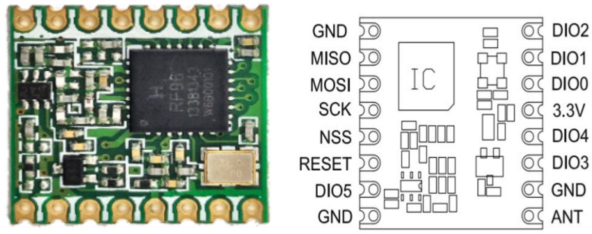



Figure 3. LoRa RFM95 Module and Circuit [10]

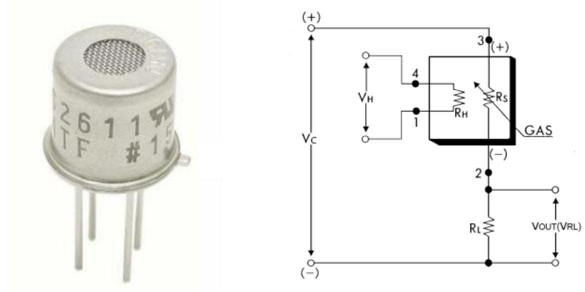



Figure 4. TGS 2611 Sensor and Circuit [11]

durability. This sensor also has the ability to measure volatile organic compounds (VOC) released by certain living creature processes. The sensing element consists of a metal-oxide semiconductor layer formed on the alumina substrate of the sensor chip along with the components heater contained in it. When the presence of gas is detected, the conductivity of the sensor increases depending on the measured gas concentration in the air. TGS 2811 is shown in Figure 4.

### *F. MQ-138 Sensor*

The MQ-138 sensor is a sensor that is sensitive to volatile organic compounds (VOCs/Aldehyde, Alkanol, Ester, Ether), n-Hexane, benzene, alcohol and hydrogen. The sensitive material of the MQ-138 gas sensor is SnO2, which has lower conductivity in clean air. When VOC compound gas detected, the sensor conductivity value will become higher as the gas concentration level increases. Change in the output signal of the response this conductivity can be done with a simple circuit. MQ-138 sensor is shown in Figure 5.

### *G. MS1100 Sensor*

The MS1100 gas sensor is a sensor that can detect gases such as benzene, toluene and formaldehyde. The working principle is to accept changes in the resistance value at the output pin when exposed to gas. When using it, you must know the sensitivity value for the gas you want to measure or the relationship between the sensor output voltage and the gas concentration value you want to measure in ppm units. MS1100 sensor is shown in Figure 6.

### *H. TGS 822 Sensor*

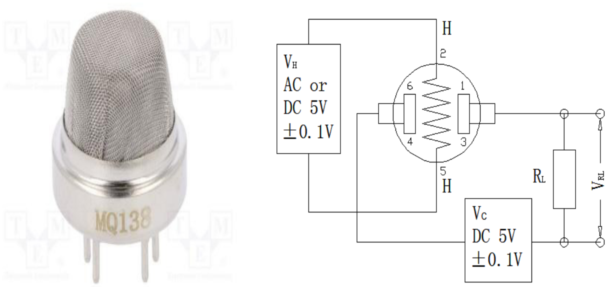



Figure 5. MQ-138 Sensor and Circuit [12]

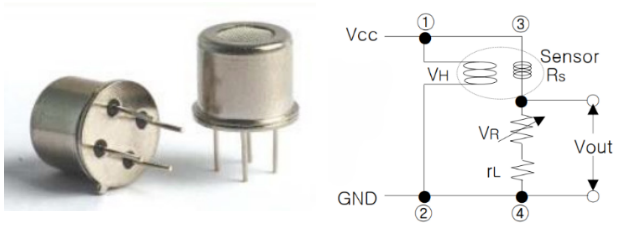



Figure 6. MS1100 Sensor and Circuit [13]

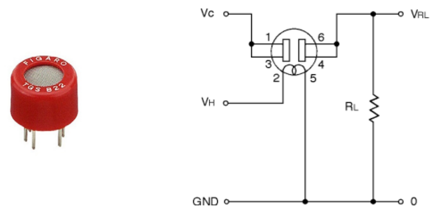



Figure 7. TGS 822 Sensor and Circuit [14]

TGS 822 has high sensitivity to organic solvent vapors and easily evaporate. TGS 822 also has sensitivity to various easy gases burns like carbon monoxide, so sensors are commonly used. Also available with a ceramic base that is highly resistant to harsh environments as high as 200 °C. TGS 822 sensor is shown in Figure 7.

### *I. Arduino IDE (Integrated Development Environment)*

Arduino IDE is software used to edit, create and insert programs on the microcontroller board. There is a library in this application which can be used to carry out programming according to the components that the tool is programming. Arduino IDE uses a special C/C ++ programming language that has been developed by Arduino developers making it easier for users to carry out programming.

### *J. Blynk*

Blynk is an open source server service which offers the ability to control devices remotely, store reading data and display data visually so it is very suitable for use in Internet of Things system applications with Android and iOS operating systems. Blynk has many each widget has a different function, starting from displaying graphic data, numbers, even images so it is very easy to read and use.

## III. Methodology

### *A. Research Work Flow*

The research method used is the research and development method. This research method is used to produce certain products and test the effectiveness of these products [15]. The research flow diagram can be seen in Figure 8.

### *B. Hardware Design*

The hardware design of this system is divided into 2 parts; (1) component design electronics; (2) physical

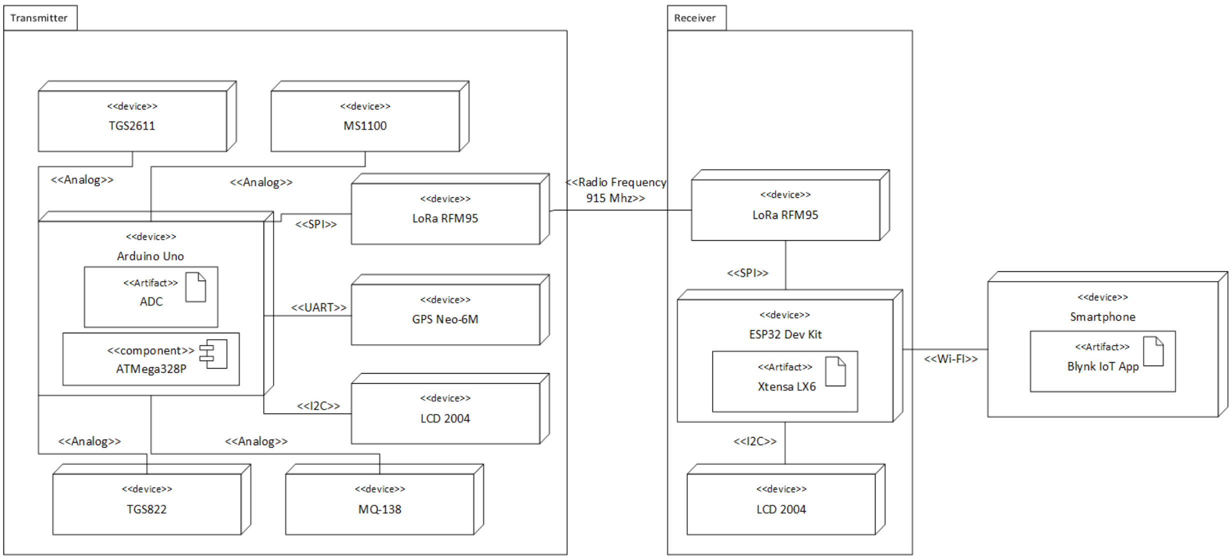



Figure 8. Flowchart

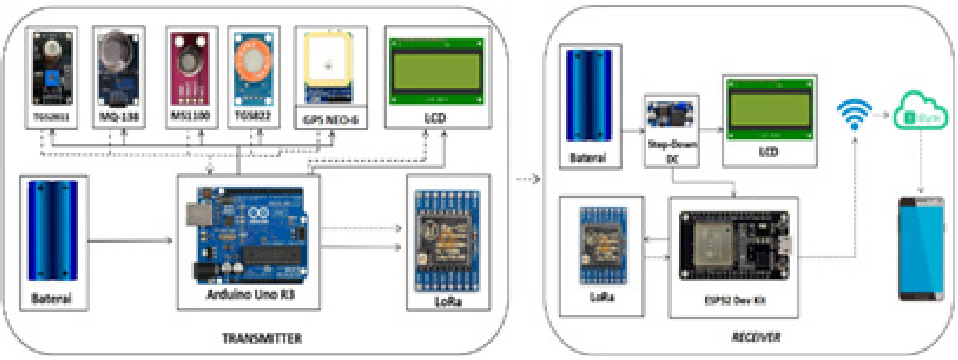



Figure 9. Hardware Design Block Diagram

design of the transmitter and receiver device. The general system tool design component block diagram can be seen in Figure 9.

## *C. Electronic Component Design*

The design of the electronics components of the system is generally divided into two, namely the transmitter device which uses the Arduino Uno microcontroller and the receiver device which uses the ESP32 Dev Kit microcontroller. The general electronic design of the system is shown in Figure 10 and Figure 11

The transmitter device is designed to have 4 VOC compound gas reading sensors with different spesifications to detect 3 compounds contained in ganoderma VOC; 2-Furan-carboxaldehyde,5-(hydroxylmethyl)-, swhich belongs to the Aldehyde group; Thiophene, 2-propyl- with and odor resembling benzene; and other organic compounds, namely 4H-Pyran-4-one. Sensors used include:

1. MS1100 sensor with the ability to read formaldehyde

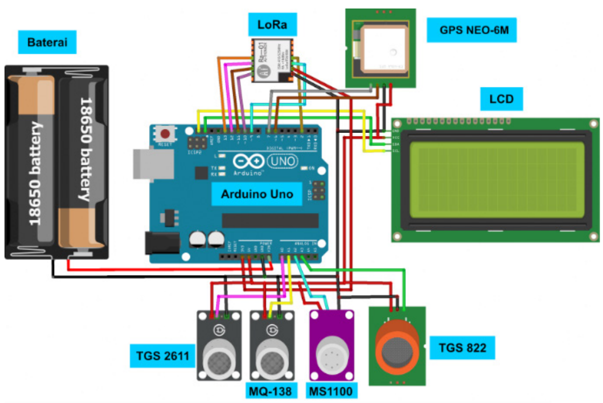



Figure 10. Transmitter Electronics Schematic Circuit

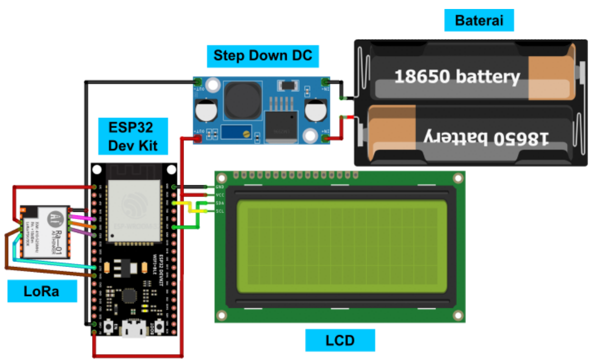



Figure 11. Receiver Electronics Schematics Circuit

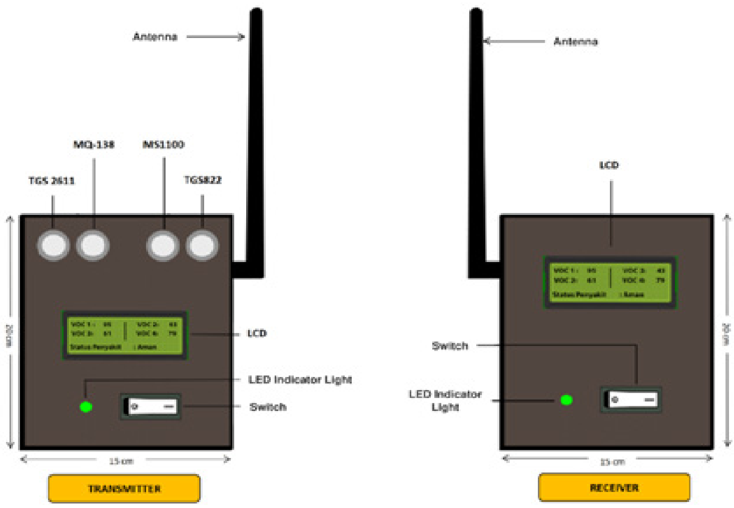



Figure 12. Display Design of a Monitoring System Tool Based on LoRa and IoT for Detecting Ganoderma Disease

gas (aldehyde), benzene and other compounds.

2. MQ-138 sensor for aldehyde gas reading, benzene, alcohol and others.
3. TGS2611 sensor which is sensitive to VOC gases, methane and other natural gases.
4. The TGS822 sensor is sensitive to dissolved organic vapors, benzene, alcohol and others.

### *D. Physical Design of Transmitter and Receiver Devices*

LoRa and IoT-based monitoring system tool design to detect ganoderma disease in oil palm plants is equipped with a framework, physical model, sensors, antennas, and LCD. body, sensors, antenna, and LCD. The device is divided into two, namely transmitter devices that are used directly on oil palm plants, and receiver devices that are placed in areas where internet networks are available. Display design of a monitoring system tool based on lora and iot for detecting ganoderma disease can be seen in Figure 12 and Figure 13.

Before this tool is used in the field, we test it first in the laboratory. Based on the test results in our laboratory which we have sterilized from gases that are feared to interfere with the validity of the test results. From the test results, the sensor can read the target at an effective distance of up to 4 cm. Therefore, this distance was used during field testing. Field testing on each sample was carried out by looking at the highest increase when the sensor was brought closer at a distance of 1 cm to 4 cm at the base of the trunk of the oil palm plant. This reading value is influenced by the sensor's ability to detect ganoderma volatile gas.

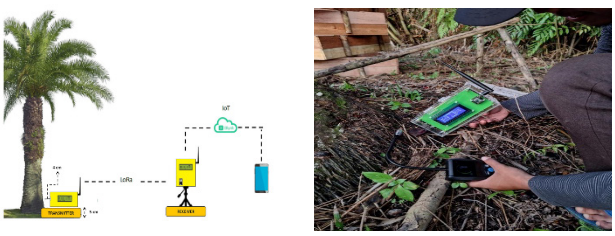


Figure 13. Design of a Monitoring System Tool Based on LoRa and IoT to Detect Ganoderma in Oil Palm Plants

### *E. Software Design*

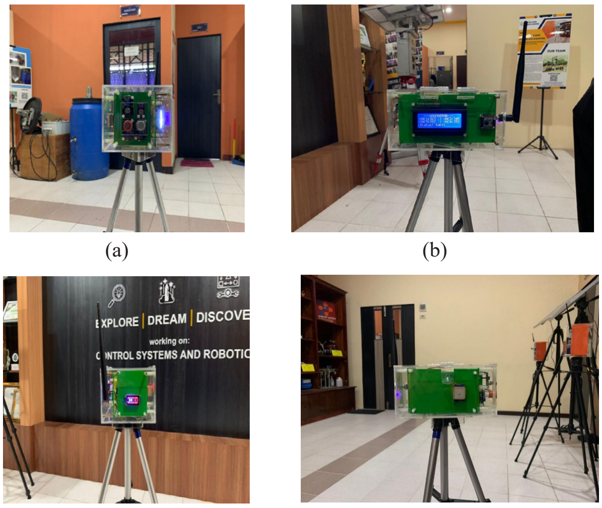
The system software consists of software design on the Arduino Uno microcontroller as the transmitter and the ESP32 Dev Kit as the receiver. The transmitter will collect data in the form of VOC gas readings by the TGS2611, MQ-138, MS1100 and TGS822 sensors. On the transmitter there is also a GPS sensor which will send coordinates when there are high VOC levels when scanning palm trees to create a mapping of palm trees suspected of being affected by disease. All sensor reading data collected in the transmitter system will be sent via the LoRa communication base to the receiver. The data that has been received by LoRa on the receiver will be converted and displayed on the LCD later forwarded to the Blynk server so that it can display data on the application in visual form.

## IV. Results and Discussion

The LoRa and IoT based monitoring system for detecting ganoderma disease in oil palm consist of hardware and software. The system hardware consists of a transmitter and receiver, while the system software is Blynk Apps.

### *A. System Hardware*

Transmitter hardware is used as a device that has components to detect VOC gas compounds from ganoderma. This device consists of sensors MQ-138, TGS 2611, TGS822 and MS1100 to determine the level of ganoderma VOC compound gas, GPS sensor NEO-6 to determine the location of the transmitter, LCD 2004 to display sensor reading results, LoRa module as a communication base, Arduino Uno as a microcontroller, battery indicator and 18650 battery as an energy source for system devices. This device uses clear acrylic material as




(a) (b)

(c) (d)

Figure 14. Transmitter Hardware (a) Front View, (b) Left Side View, (c) Back View, (d) Right Side View

an outer casing that protects the components. Transmitter hardware which has been assembled is shown in Figure 14.

The receiver hardware is used as a device to receive data sent by the transmitter device via the LoRa communication network. This device consists of a LoRa module as a communication base that receives data from the transmitter, ESP32 Dev Kit as a data processing microcontroller, LCD 2004 to display the reading results received by the device, a battery indicator, and an 18650 battery as an energy source for the system device. This device uses materials clear acrylic as outer casing to protect components. The receiver hardware that has been assembled is shown in Figure 15.

## B. System Software

The creation of the system software interface was carried out on Blynk Apps for smartphone interfaces. The Blynk Apps interface uses map widgets, graphs and an LCD to display the results of sensor readings and the health status of oil palm trees. The chart graph widget each displays ADC value reading data for each sensor in graphic form that can display real-time data. The Blynk interface also uses a map widget to display transmitter location points from GPS sensor readings. The system


(a) (b) (c)

Figure 15. Receiver Hardware (a) Front View, (b) Left Side View, (c) Back View, (d) Right Side View

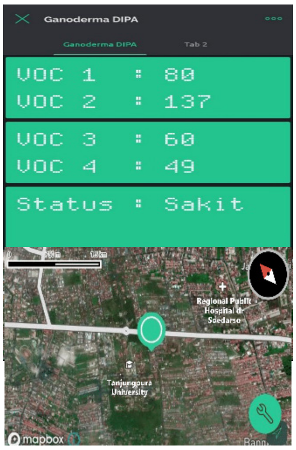



Figure 16. Blynk Apps Interface

software interface image is shown in Figure 16.

## C. How to Sensor Works

The way the VOC compound gas sensor works is similar to the human nose, namely recognizing gases that are around it. The use of four sensors with different specifications was carried out to increase the sensitivity of the tool to VOC compound gases and anticipate an increase in other gases that could cause reading errors. Therefore, the ganoderma attack level reading is obtained from the total ADC (analog to digital converter) readings of the four sensors. This value is obtained from converting the output voltage from each sensor reading into an analog value with the equation

$$ADC\ value = \frac{OutputVoltage}{ReferenceVoltage} \times ADCMax \qquad (1)$$

## D. Data from Sensor Testing Results on Ganoderma Disease Samples

Testing was carried out on samples of palm tree trunks that were known to be infected with ganoderma disease. Samples are taken from the trunk of an oil palm tree as a result of field testing to be tested at a certain distance from the sensor, then calibration is carried out to adjust the health category of the oil palm plant based on the ADC sensor data. Sensor testing is carried out by taking reading data in varying distances and varying times to determine the optimal point for sensor readings. The sensor readings are programmed to send data within 5 seconds on a single reading. The results of sensor readings on ganoderma disease samples are shown in Figure 17 and Table 1.

Based on data from Table 1, it is known that there was an increase in the four sensors with variations in the given distance. The lowest recorded reading of the four sensors was at a distance of 6 cm. Meanwhile, the highest recorded reading of the four sensors was at a distance of 1 cm. An increase in value can occur when the test sensor is brought close to the sample because the sensor detects the presence of volatile gases released from samples of diseased oil


Figure 17. Collecting Sensor Reading Data on Samples

palm stems. The closer the reading distance, the higher the sensor reading value and the farther the reading distance, the lower the sensor reading value. Caused by gas the reading is not up to sensor sensing element for long distances resulting in a reduction in value. So it can be seen from this data that the sensor's limitations are only a maximum reading distance of 4 cm. Sensor readings at an optimal distance of 1 cm - 4 cm for stem samples diseased oil palm plants produced the lowest total ADC value of 300 and the highest total ADC value of 328.

### *E. Sensor Test Results Data on Ganoderma Mushroom Samples*

Testing of ganoderma mushroom samples was carried out by taking 4 different samples of ganoderma mushrooms. There was a significant increase in the sensor reading values for the ganoderma samples. This increase in value can occur because the ganoderma sp contains the compound1-octen-3-ol (69,43%) which is also known as mushroom alcohol, 3-octanone (10,34%), 1-octanol and (E)-2-octenal (20,23%) which can be read by the sensor [16].

Table 1. Ganoderma Sample Value Reading Data

| Sample | Range (cm) | Time (s) | ADC Value | | | |
|---|---|---|---|---|---|---|
| | | | TGS2611 | MS1100 | TGS822 | MQ-138 |
| 1 | 1 | 5 | 70 | 101 | 98 | 52 |
| 2 | | 10 | 71 | 100 | 102 | 52 |
| 3 | | 15 | 71 | 103 | 101 | 52 |
| 4 | 2 | 5 | 70 | 102 | 100 | 54 |
| 5 | | 10 | 70 | 102 | 97 | 51 |
| 6 | | 15 | 69 | 100 | 95 | 52 |
| 7 | 3 | 5 | 70 | 97 | 94 | 51 |
| 8 | | 10 | 68 | 99 | 95 | 51 |
| 9 | | 15 | 65 | 98 | 96 | 50 |
| 10 | 4 | 5 | 64 | 96 | 92 | 51 |
| 11 | | 10 | 63 | 93 | 95 | 49 |
| 12 | | 15 | 66 | 95 | 93 | 49 |
| 13 | 5 | 5 | 65 | 84 | 79 | 43 |
| 14 | | 10 | 66 | 81 | 77 | 44 |
| 15 | | 15 | 64 | 80 | 73 | 44 |
| 16 | 6 | 5 | 63 | 80 | 75 | 46 |
| 17 | | 10 | 62 | 79 | 76 | 42 |
| 18 | | 15 | 63 | 79 | 75 | 43 |

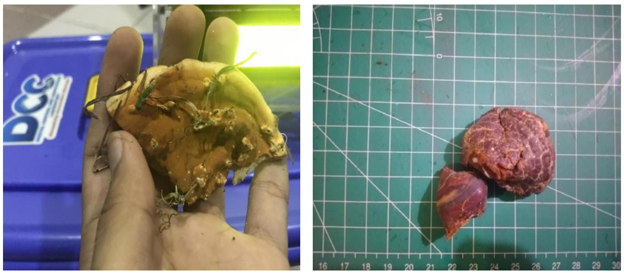
Each sample has a different reading value. The lowest value in reading the ganoderma mushroom sample is a total ADC value of 242 with an increase in the ADC value of 22, while the highest value is a total ADC of 336 with an increase in the value of 67. This difference in values is influenced by the maturity of the ganoderma mushroom which is indicated by the size and color of the mushroom. In young mushroom, the fruit body is red with yellow edges and will turn brownish red when it is old [17].

In this research, four different gas sensors are used so that the research results can be scientifically accounted for. There are four gas sensors in the system used to detect ganoderma disease. Because it uses different sensors, the consequence is that each sensor reading will also give a response in the form of a different voltage (analog) value change, where the more gas detected, the higher the analog value read. This analog value must be converted as a digital value so that it can be understood by Arduino (microcontroller) through an analog to digital conversion system/analog digital converter (ADC). This ADC value is used as a parameter for disease severity during detection, so each sensor reading is identified with ADC1 (TGS2611), ADC2 (MS1100), ADC3 (TGS822), and ADC4 (MQ-138).

The use of four sensors with different specifications is done to increase the sensitivity of the device to VOC compound gases and anticipate an increase in other gases that cause reading errors. For example, if the increase occurs in one of the sensors, the gas read by the device may not come from volatile ganoderma. However, if the increase occurs in four sensors with relatively the same increase, then the gas read is volatile gas. Therefore, to determine whether the plant is diseased or not based on the increase in ADC value that occurs in the four sensors is through the difference between the initial ADC and final ADC values, where the term initial ADC value is used which is the sum of ADC1, ADC2, ADC3 and ADC4 values before being tested (closer to the sensor target); while the final ADC is the highest value of the sum of ADC1, ADC2, ADC3 and ADC4 values when tested on the sensor target. This is a preliminary study where we tried to make a tool to test the presence of Ganoderma volatile gas caused by stem base rot disease. We agree that more samples are needed in this research as well as more variations such as the volume and age of the mushrooms. In the early stages of this research, we focus on whether or not the tool we have made works. In this research, we also have to test the effectiveness of the right sensor selection, testing the communication module between devices, testing the reading of the disease location point via GPS, testing data transmission via the internet, and testing the battery as a system energy resource. The next step that we plan to take is of course to develop the tools that we have made with more systematic testing. The results of ganoderma samples are shown in Table 2 and Figure 18.

Table 2. Data from Testing Results for Ganoderma Mushroom Samples

| Sample | Initial ADC | Final ADC | Enhancement ADC value |
|---|---|---|---|
| Ganoderma sp 1 | 269 | 336 | 67 |
| Ganoderma sp 2 | 216 | 249 | 33 |
| Ganoderma sp 3 | 220 | 242 | 22 |
| Ganoderma sp 4 | 214 | 244 | 30 |



(a) (b)

Figure 18. Ganoderma Sample; (a) young, (b) old

*F. Non Target Sensor Test Results Data*

Non-target sensor testing is carried out to determine the increase in value that occurs on the sensor as a result of other components that occur when reading the sensor on oil palm plants. Based on the data obtained, there was no significant increase in sensor testing on samples of dead oil palm plants not due to ganoderma. Therefore it is known that land and the death of oil palm plants is not due to ganoderma included in the target that influences the sensor reading results.

From several target and non-target sample data that have been obtained, a calibration is made for the plant health category based on the optimal total ADC value, namely at a reading distance of 1 cm to 4 cm where the target sensor reading value is at the lowest total ADC value of 242, and the highest at 336. Meanwhile, the average increase in the value of the sensor target sample from healthy to sick was 40.2. So the health category values are obtained as follows:

1. Healthy : ADC Total $\leq 245$
2. Moderate : $245 <$ ADC Total $\leq 285$
3. Sick : ADC Total $> 285$

*G. Data from Sensor Testing Results on Palm Oil Plants*

Sensor target testing is a test carried out by bringing the sensor used close to the base of the oil palm trunk and the ganoderma disease sample to determine the sensor's ability to detect ganoderma VOC compounds. Based on the test results which can be seen in Table 3. In sample of the first tree, there was no significant increase between the initial and final ADC values, which indicates that there are minimal volatile gas readings so it can be seen that the oil palm plant is healthy. The value increased significantly when the sensor was brought closer to sample of third tree, where the initial ADC before testing was 228, increasing to 299 when the sensor was brought closer to the trunk sample of third tree, indicating that the tree had been affected by ganoderma disease and was emitting a lot of volatile gases. Apart from the volatile gas readings, at the base of the plant stem there are ganoderma sp fruit bodies thereby increasing the sensitivity of the sensor in reading data.

Table 3. Sensor Testing Data on Oil Palm Plants

| Sample | Initial ADC | Final ADC | Enhancement ADC value | Status |
|---|---|---|---|---|
| First | 224 | 228 | 4 | Healthy |
| Second | 231 | 285 | 54 | Moderate |
| Third | 228 | 299 | 71 | Sick |
| Fourt | 227 | 270 | 43 | Moderate |

Samples of the second tree and fourth tree are categorized as "moderate" because they are close to diseased plants, but have not shown significant symptoms in the form of the appearance of ganoderma fruit bodies on the plant stems. The increase in reading values around sick plants is influenced by the ganoderma attack pattern, namely through spores and root contact. Spread via spores (ganoderma baciliospores) can carry ganoderma spores through the air where the number in the air is always abundant compared to other fungi, making the spread of ganoderma disease most susceptible to occurring around diseased plants [18]. The results of sensor testing in oil palm plants are shown in Table 3.

*H. Testing LoRa RFM95 Connection from Transmitter to Receiver*

LoRa RFM95 testing is carried out by placing the transmitter and receiver devices at different distances. This test uses a 915MHz frequency and a LoRa 5 db Omni antenna. LoRa RFM95 communication testing was carried out on Jalan Sepakat II Kelurahan Kecamatan Pontianak Tenggara, Kota Pontianak with reading distances between devices ranging drom 250 meters, 500 meters, 600 meters, 800 meters, 1000 meters and 1200 meters. The location selection was carried out with the consideration of minimal obstacles and having a straight road that was far enough away so that the maximum distance beetween LoRa could be obtained. The receiver will be placed at a point of 0 meters with a height of 150 cm from the ground and the transmitter will be moved away from the receiver until communication between LoRa reaches the maximum distance to obtain the RSSI (Received Signal Strength Indication) value. From the test that have been carried out, the LoRa RFM95 communication reading results are obtained as in Figure 19 and Figure 20.

Based on the test results, it is known that the greater the distance between LoRa devices, the smaller the RSSI value. The smaller the RSSI value, the signal strength received in the transmission system has a worse signal quality [19]. Tests that have been carried out are in areas with minimal obstacles to determine the potential of the


Figure 19. LoRa RFM95 Communication Test Range Distance


(a) (b)

Figure 20. (a) Transmitter device that is carried away from the Receiver, (b) Receiver device receives data and displays RSSI value (b).

LoRa communication module in sending data by placing the receiver device at a certain point with a height of 150cm from the ground. While the transmitter device is brought away while still sending data to each other until it reaches the farthest point the two devices can communicate. When the receiver receives data from the transmitter, the receiver will display the RSSI (Received Signal Strength Indication) value, where the further the distance between LoRa devices, the smaller the RSSI value. The smaller the RSSI value, the signal strength received in the transmission system has a worse signal quality. From the research conducted, a maximum distance of 1,256.5 meters was obtained (RSSI = -121 dBm) with minimal obstacles. Differences in maximum distance can occur if testing is carried out in different conditions such as oil palm plantations with many horizontal obstacles in the form of trees.

### *I. Testing the Length of Time for Sending and Receiving LoRa RFM95 Data from the Transmitter to the BIynk IoT Receiver*

The LoRa RFM95 sending time test was carried out to determine the time difference that occurs when the data is sent between the LoRa sending (transmitter) and LoRa receiving (receiver) devices. Testing was carried out by connecting both transmitter and receiver devices to the laptop using a serial cable to obtain timestamp data on the Arduino IDE serial monitor. The difference in time for sending and receiving data between LoRa RFM95 devices is calculated based on the time recorded on the Arduino IDE serial monitor connected to the device.

It is known that there is a difference in data sending and receiving times between LoRa devices. The average time difference that occurs is 0,894 seconds. So it is known that with an average time of 0,894 seconds, the RFM95 LoRa module can send data between two devices, namely LoRa transmitter and receiver devices. Test are also carried out to find out long transmission time between the receiver device and Blynk IoT. On the receiver device, data can be obtained up to an accuracy of 0,000 seconds which can be displayed on the serial monitor, whereas on Blynk IoT data can only be obtained up to an accuracy of 0 seconds. The average time difference that occurs in the process of sending and receiving data between the receiver device and Blynk IoT is 0,563 seconds. There is a difference is unstable time data between sending and receiving time data. Influenced by differences in accuracy in the given time format and internet access speed on the device which affects the speed of data transmission in the Blynk IoT application. The difference in the length of time that occurs does not show a significant difference with the difference in average data sending and receiving.

### *J. Testing GPS Sensor Location Data*

The transmitter device uses the Neo-6 GPS sensor to determine the transmitter location point. The data sent by the Neo-6 GPS sensor is altitude data and longitude so that you can identify the location points on the map and record the mapping of areas of oil palm plants affected by ganoderma disease. Based on the test results, the GPS sensor requires time to find out valid latitude and longitude point data from the satellite. The GPS sensor results show the latitude value -0,062516 and longitude 109,248716 can be seen in Figure 21 and Figure 22. After getting the altitude and longitude values, these values are tested to be sent to the receiver device and uploaded to the Blynk application to provide the latest location points on the map widget. The test results show that there is a

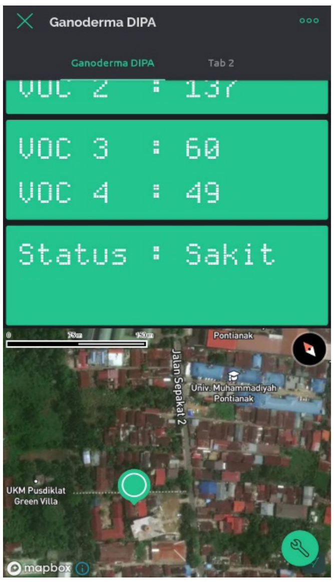
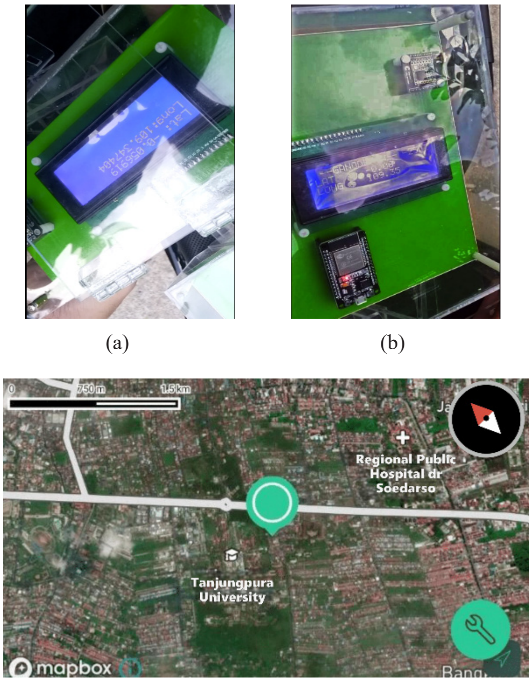



Figure 21. GPS Sensor Test Results on the BIynk Map Widget




(a) (b) (c)

Figure 22. (a) GPS sensor location point detection results in the form of latitude and longitude on the device; (b) GPS sensor location result value received by the receiver device; (c) GPS sensor location points received and displayed on the Blynk IoT app Map widget

difference between the actual location and the location on the Blynk Apps map with a shift of 12.4 meters. This is influenced by two things, namely the ability to read the GPS Neo-6 sensor to determine altitude and longitude points accurately, and there is compression of data sent via LoRa by the transmitter to the receiver.

GPS module testing has also been carried out in the same area as LoRa testing where it is related to the communication system. When the GPS sensor detects the latitude and longitude location point, the value will be sent by the transmitter device to the receiver device via LoRa communication. This value will then be forwarded by the ESP32 on the receiver to the Blynk application on the user's smartphone so that it displays the test location point on the user's smartphone screen. Based on the tests conducted, the sensor can read the data well and can be communicated and sent the data well with minimal obstacles. The value may be different if the GPS sensor is used in conditions where there are vertical obstacles such as in rooms or areas with dense trees.

## V. Conclusion

Based on the test results of the pre-symptom detector system for oil palm stem rot (*ganoderma*) based on LoRa and IoT, it is known that the ganoderma disease detection system with the TGS2611, MS1100, TGS822 and MQ-138 sensors can detect the level of volatile organic compounds from *ganoderma* with the results; The optimal distance for sensor readings for oil palm plants is in the range of 1 cm to 4 cm, sensor testing on non-target component such as soil and dead palms not due to *ganoderma*. Resulting in minimal total ADC increase. Sensor testing on *ganoderma* mushrooms resulted in an increase in total ADC between 22 – 67 according to the maturity level of the *ganoderma* mushroom body and the test sensors with optimal distances result in an increase in the total ADC value in healthy oil palm plants; currently; and sick.

The LoRa and IoT based monitoring system to detect *ganoderma* disease attacks on oil palm plants can send data from the transmitter to the receiver with a range of up to 1,256.5 meters with an RSSI value of -121 dBm in conditions of minimal obstacles. The difference in time for sending and receiving data between LoRa RFM95 transmitter and receiver devices has an average of 0.894 seconds and the difference in time for sending and receiving data between receiver devices and Blynk IoT has an average of 0.563 seconds. And the Neo-6 GPS sensor can carry out mapping on the Blynk IoT application with a point shift of 12.4 meters from the actual location.

Suggestions that can be given for developing a pre-symptom detector system for palm stem rot disease (*ganoderma*) based on LoRa and IoT are to adjust the position and distance between sensors so that the volatile gas readings that hit the tool can be read optimally by all sensors so that the readings are more accurate, make modifications so that the sensor used can reach the inside of the palm trunk with as little distance as possible and use an antenna with a higher gain to obtain a longer reading range.

## Reference

[1] Direktorat Statistik Tanaman Pangan, Hortikultura, dan Perkebunan: "Statistik kelapa sawit Indonesia". 2020. Jakarta: Badan Pusat Statistik Indonesia.

[2] Evizal, Rusdi., Prasmatiwi, Erry, and Fembriarti, "Penyakit busuk pangkal batang dan performa produktivitas kelapa sawit". *Jurnal Agrotropika*, vol. 21, no.1, pp. 47-54, 2022.

[3] Priwiratama, Hari, Susanto, Agus. "Kejadian penyakit busuk pangkal batang pada tanaman belum menghasilkan varietas toleran ganoderma dengan sistem lubang tanam standar". *WARTA Pusat Penelitian Kelapa Sawit*, vol. 25, no.3, pp. 115-122, 2020.

[4] Sundram and Shamala "Ganoderma: research advances, management and future challenges". In Proc International Oil Palm Conference, 2018. pp. 35-36.

[5] A. S. Mulyatni, I. Kresnawaty, D. D. Eris, T. Panji, W. Kimberly, H. Widiastuti, and K. Triyana, "Potensi *electronic nose* 118 untuk mendeteksi penyakit busuk pangkal batang pada kelapa sawit", *Menara Perkebunan*, vol. 90, no. 1, 2022.

[6] A. D. Muhaimin, F. Hadary, I. Suswanto, "LoRa and IoT Based Monitoring System for Detecting Ganoderma Disease Attacks on Oil Palm Plants," *Journal of Electrical Engineering, Energy, and Information Technology*, vol. 11, no. 3, pp. 158-169, 2011.

[7] M. N. Muttaqin, "Pengaruh suhu pada Chamber Volatile Organic Compounds (daging sapi dan daging babi) berbasis electronic nose dengan menggunakan metode Linear Discriminant Analysis (LDA)", Doctoral dissertation, Universitas Islam Negeri Maulana Malik Ibrahim, 2018.

[8] Arduino. cc. 2022. Arduino® UNO R3 *Datasheet.*

[9] Espressif System (Shanghai) Co. 2022. ESP32 WROOM-1

*Datasheet.*

[10] HOPE Microelectronics Co. 2018. LoRa RFM95 *Datasheet.*

[11] Figaro Engineering Inc. TGS 2611 Natural Gas Sensor *Datasheet.*

[12] Zhengzhou Winsen Electronics Technology Co. 2015. MQ138 *Datasheet.*

[13] W. U. Zong-Kui and F.A.N. Yu-Feng, "Design of toxic and harmful gas monitoring system based on machine learning method", *Fire Science and Technology*, vol. 39, no.11, pp. 1550, 2020.

[14] O. A. Putra. "Identifikasi Aroma Teh dengan E-Nose Menggunakan Metode Backpropagation". Doctoral Dissertation. Universitas Andalas, 2016.

[15] D. Sugiyono, "Metode penelitian pendidikan pendekatan kuantitatif, kualitatif dan R&D". Bandung: Alfabeta, 2013.

[16] N.H.Z. Hilmi, A.S. Idris, M. N. M. Azmil, "Headspace solid-phase microextraction gas chromatography-mass spectrometry for the detection of volatile organic compounds released from Ganoderma boninense and oil palm wood", *Forest Pathology*, vol. 49, no.4, pp. 1-4, 2019.

[17] F. Nisah, "Pengaruh Penambahan Berbagai Konsentrasi Naa Terhadap Pertumbuhan Miselium F0 Jamur Ling Zhi (*Ganoderma Lucidum)* Pada Media Air Kelapa Sebagai Kajian Sumber Belajar". Tesis, Universitas Muhammadiyah Malang, 2019.

[18] A. Susanto, A. E. Prasetyo, H. Priwiratama, S. Wening, and S. Surianto, "Ganoderma boninense penyebab penyakit busuk batang atas kelapa sawit". *Jurnal Fitopatologi Indonesia*, vol. 9, no. 4, pp. 123-123, 2013.

[19] H.R. Maulida, F. T. Syifa, M. A. Affandi, "Pengujian sistem RSSI pada perancangan prototype pemantauan lahan kebun teh berbasis LoRa". *Journal of Telecommunication, Electronics, and Control Engineering*, vol. 4, no. 2, pp. 117-127, 2022.