IoT-Based Rainfall Monitoring System for Chili Farming Land

Rahmadani Putri\textsuperscript{1}, Ratna Dewi\textsuperscript{2}, Silfia Rifka\textsuperscript{3}, Sri Nita\textsuperscript{4}, Andi Ahmad Dahlan\textsuperscript{5}
\textsuperscript{1,2,3,4,5}Politeknik Negeri Padang, Indonesia
\textsuperscript{1}rahmadanip2512@gmail.com, \textsuperscript{2}ratnadewi@pnp.ac.id, \textsuperscript{3}silfia_rifka@pnp.ac.id, \textsuperscript{4}srinita06l0@gmail.com, \textsuperscript{5}aadfiaty@pnp.ac.id@email.com

ABSTRACT
This research focuses on the design and implementation of a rainfall monitoring system for chili pepper farms using Internet of Things (IoT) technology. The rainfall monitoring system consists of a transmitter system, a receiver system, the Thingspeak platform as a database, and a weather station application that can be accessed via a mobile device. The weather station application is built using the MIT App Inventor platform. In the testing phase, the system successfully collected data from two sensors used, namely the rainfall intensity sensor and the raindrop sensor. The test results showed that the data obtained from the rainfall intensity sensor was 0.25 inches and the raindrop sensor was 1. This result shows that there was no rain during the test. This rain intensity and raindrop data can provide farmers with an overview of the weather conditions in the chili pepper farm. So, with this rainfall monitoring system, farmers can monitor the condition of their agricultural land in real-time. The collected data can help farmers to care for chili pepper plants more effectively and adapt to environmental changes. In addition, this system is expected to increase the productivity of chili pepper farming because it uses a more precise and responsive approach to changes in environmental conditions on the chili pepper farm.

INTRODUCTION
Indonesia has a tropical climate because it crosses the equator. The weather conditions in Indonesia are unpredictable when the rainy season and the dry season will come, so weather forecasts are needed, especially regarding the intensity of rain. Extreme weather conditions can be fatal for the aviation, marine, and community environments, especially farmers (Delian Fazira, 2022).

Agriculture is the backbone of food supply for the Indonesian people. The Indonesian government continues to strive to improve the productivity of Indonesian agriculture. If land, labor, and other resources can produce larger harvests, Indonesia can produce more food and increase the income of rural communities (Suwarti Suwarti, 2017). One of the reasons for the low productivity of Indonesian agriculture is that most Indonesian farmers still rely on climate change to cultivate their agricultural land. An example is chili cultivation.

Chili peppers are vegetables that are indispensable for daily use. Quoted from kompas.com, chili plants grow slowly because they do not meet the ideal growth requirements for tropical plants, including insufficient temperature and lighting, improper watering, poor soil, diseases, pests, and improper pruning cause chili to grow slowly (Sakina Rakhma Diah Setiawan, 2022).

However, monitoring of chili pepper fields is currently still manual. Therefore, the land and weather data obtained may not have a high accuracy value. In today's digital age, society is in great need of a device that is practical and easy to use to obtain accurate weather information (Ferawati, 2022).

The background of this research is based on the problems faced by onion and chili farmers in the Alahan Panjang area, West Sumatra. In this area, many farmers cultivate onions, chilies, tomatoes, and others. Based on field surveys and discussions with landowners, there are several obstacles for farmers in carrying out the seeding process to the harvesting process of plants which are an important need for society for daily consumption. The obstacles faced are how to maintain soil moisture and irrigation conditions which must be monitored and controlled periodically and manually and traditionally, so this makes farmers have to be diligent and routine in monitoring their agricultural land so that they do not fail to harvest because the above factors cannot be met.

LITERATURE REVIEW
A similar study was also conducted by Raudhotul Jannah in 2021 (Raudhotul Jannah, 2021). This research aims to assist chili farmers in overcoming plant diseases caused by excessive water from rain, by creating an automatic roof control system for chili plants. Meanwhile, this study will monitor chili agricultural land. Therefore, this research will be conducted to observe sensor readings, meaning that the data read by the sensor will be processed on the microcontroller and then sent to the software. This research will discuss a rain monitoring system for chili pepper
plantations using the IoT ThingSpeak platform. The aim of this research is to design and build a hardware and software system for monitoring rain in chili pepper plantations based on IoT. This research is also useful to assist farmers in monitoring chili pepper plantations. So that farmers know the environmental conditions of the plants, and can be followed up by farmers with appropriate care.

METHOD

In this research, a method has been developed with the aim of clarifying the research flow to be carried out. Figure 1 below illustrates the flowchart of the research on the IoT-based rainfall monitoring system in farm land.

![Research Flowchart](image)

**Problem identification**

Based on discussions with farm owners, farmers face obstacles in harvesting chili plants for community needs due to the still manual monitoring of chili farming. Factors such as humidity, soil pH, fertilization, and rainfall must be monitored regularly, causing crop yields to be affected and pest attacks not detected in time. There is a need to improve monitoring technology such as sensors or data analysis to obtain more accurate information and help farmers optimize yields and deal with environmental challenges more effectively.

Based on these conditions, technology is needed to help farmers monitor agricultural land remotely without having to go to the farm. This technology utilizes the IoT platform, namely ThingSpeak (Haridha Narulita Kusman, 2022). ThingSpeak functions to display data from rain intensity sensors. Thus, it can be monitored by farmers through their smartphones without having to go to the farm.

**System Design**

In the design of a rain monitoring system for chili agricultural land, there are several parts, including a data sending system, a data receiving system, an IoT platform, and an Android application. Figure 2 shows a block diagram of the system design.
Preparation of Materials and Equipment

1. Arduino Mega 2560
   Arduino Mega 2560 as a microcontroller for data processing (Jauhari Arifin, 2016). The data comes from the reading of rain sensors, namely rain intensity and raindrop sensors. Here is an image of the Arduino Mega 2560.

2. Arduino UNO
   Arduino UNO is a microcontroller board based on the ATmega328 (Hidyatama, 2013). As a microcontroller, Arduino Uno functions to process data from the sender system. Here is an image of Arduino Uno.

3. Raindrop Sensor and Rainfall Intensity Sensor
   Rain drop sensor is a device that can detect rain (Darmawan, 2020). The working principle of this module is when the rain water hits the sensor, an electrolysis process occurs, where the liquid flows an electric current. Here is an image of the rain drop sensor.

A rainfall intensity sensor is a type of weather sensor used to measure the intensity of rainfall (Muhammad Syahbeni, 2018). Rainfall intensity sensors are used in weather stations to monitor rainfall intensity and provide important information about rainfall patterns in an area. The following is an image of a rain intensity sensor.
4. ESP-01 Module
The ESP-01 module is a WiFi serial transceiver microcontroller that can work with other microcontrollers or independently. The ESP-01 has an internal storage capacity of 1 MB (Budi Setiyono, 2022). Here is an image of the ESP-01 module.

![ESP-01 Module](image)

5. LoRa E32
LoRa is a communication method that can reach long communication distances, but with low energy consumption and data volume (Fadli Padriyana, 2021). LoRa E32 is used to send data from the transmitter system to the receiver system. Figure 5 shows the layout of the LoRa E32 module.

![LoRa E32](image)

6. Internet of things (IoT)
IoT is a system of interconnected computing devices, mechanical and digital machines, objects, animals or people that are provided with unique identifiers and the ability to transfer data over a network without requiring human-to-human or human-to-computer interaction (Mr. Hecini Oussama, 2020). The image below shows the components of IoT.

![Core Components of IoT](image)

7. ThingSpeak
ThingSpeak provides a service for collecting, storing, and analyzing data from various sources of IoT devices (Kaustav Bandyopadhyay, 2019). Thingspeak.com serves as a data collector that comes from microcontroller devices in the form of sensors that are already connected to the internet. The following shows the ThingSpeak interface.
8. MIT App Inventor

MIT App Inventor is an open-source web application supported by Google and maintained by the Massachusetts Institute of Technology (MIT) (Ketty Siti Salamah, 2020). MIT is a tool for creating Android apps using visual programming that allows anyone to create apps for smartphones.

System Development and Testing

The development of an IoT-based rainfall monitoring system for agricultural land in this study is divided into several parts, namely the data transmission system, the data receiving system, data display on ThingSpeak, and monitoring through an Android application.

Data transmission system

In this system, data read by the rain intensity and raindrop sensors will be forwarded to the Arduino Mega 2560 microcontroller. On the Arduino Mega 2560, the data will be processed and then sent to the LoRa E32 module. The LoRa E32 module acts as a Transmitter in the data sending system. The image below shows the transmitter system circuit.
Data Receiving System

In this system, data sent through the LoRa E32 module on the transmitter system will be received by the LoRa E32 on the receiver system. The received data will be sent and processed through the Arduino Uno microcontroller. After the data is processed, it will be forwarded to the ESP-01, which acts as a WiFi module. The following is a diagram of the data receiver system.

![Data Receiving System Diagram](image)

Figure 13. Data Receiving System

ThingSpeak

Data received by the receiver system is sent to ThingSpeak via the ESP-01 module. The data is then displayed on ThingSpeak. ThingSpeak displays 2 channels according to the input on the system using 2 sensors. Data that has been received by ThingSpeak is forwarded to the application that has been created. Figure 14 shows the ThingSpeak channel display.

![ThingSpeak Channel](image)

Figure 14 ThingSpeak Channel

MIT App Inventor

MIT App Inventor is a platform for creating Android-based applications. The application can be downloaded on Android. The application is called Weather Station. This application will receive data from ThingSpeak which contains sensor reading data on rain intensity and raindrops. This application can be used to monitor the condition of chili agricultural land remotely. Figure 15 shows the appearance of the Weather Station application.
Tool making

Figure 16 shows the design of the device in this study. Arrow number 1 shows the rain intensity sensor, arrow number 2 shows the panel box for the transmitter system, and arrow number 3 shows the receiver system box. The raindrop sensor is located on the transmitter system box. Figures 17 and 18 show the transmitter and receiver system boxes.
RESULT

After testing the system shown in Figure 12, which is the data transmitter system, and Figure 13, which is the data receiver system, the following results were obtained:

<table>
<thead>
<tr>
<th>Day/Date</th>
<th>Time</th>
<th>Condition</th>
<th>Rain/No Rain</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wednesday, 16 Aug</td>
<td>14:09</td>
<td>1</td>
<td>No Rain</td>
</tr>
<tr>
<td></td>
<td>14:19</td>
<td>0</td>
<td>Rain</td>
</tr>
<tr>
<td></td>
<td>14:31</td>
<td>1</td>
<td>No Rain</td>
</tr>
<tr>
<td></td>
<td>14:32</td>
<td>0</td>
<td>Rain</td>
</tr>
<tr>
<td></td>
<td>14:34</td>
<td>1</td>
<td>No Rain</td>
</tr>
<tr>
<td></td>
<td>14:40</td>
<td>1</td>
<td>No Rain</td>
</tr>
<tr>
<td>Friday, 18 Aug</td>
<td>11:52</td>
<td>1</td>
<td>No Rain</td>
</tr>
<tr>
<td></td>
<td>12:29</td>
<td>1</td>
<td>No Rain</td>
</tr>
<tr>
<td></td>
<td>12:48</td>
<td>1</td>
<td>No Rain</td>
</tr>
<tr>
<td></td>
<td>13:05</td>
<td>1</td>
<td>No Rain</td>
</tr>
<tr>
<td></td>
<td>13:44</td>
<td>1</td>
<td>No Rain</td>
</tr>
<tr>
<td></td>
<td>14:48</td>
<td>1</td>
<td>No Rain</td>
</tr>
<tr>
<td></td>
<td>14:22</td>
<td>0</td>
<td>Rain</td>
</tr>
<tr>
<td></td>
<td>14:50</td>
<td>0</td>
<td>Rain</td>
</tr>
<tr>
<td></td>
<td>15:00</td>
<td>1</td>
<td>No Rain</td>
</tr>
</tbody>
</table>

Based on the reading of the raindrop sensor, which can be seen in Table 1, the raindrop sensor only outputs the numbers 1 and 0, where 1 indicates no rain and 0 indicates rain. On Wednesday, August 16, 2023, at 14:09 WIB and 14:19 WIB, the no-rain condition indicated that it rained for approximately 20 minutes until 14:31 WIB. On Friday, August 18, 2023, rain was also detected from 14:22 WIB to 14:50 WIB, with the rain lasting approximately 30 minutes. This sensor will detect rain when raindrops hit the surface of the sensor.
Rainfall Intensity Sensor Testing

Table 2. Rain Intensity Sensor Readings

<table>
<thead>
<tr>
<th>Day/Date</th>
<th>Time</th>
<th>Inch</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wednesday, 16 Aug</td>
<td>14:10:20</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>14:20:40</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>14:30:25</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>14:31:51</td>
<td>94.00</td>
</tr>
<tr>
<td></td>
<td>14:32:37</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>12:28:07</td>
<td>0</td>
</tr>
<tr>
<td>Friday, 18 Aug</td>
<td>12:48:55</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>13:05:14</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>13:44:34</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>14:19:19</td>
<td>0.25</td>
</tr>
<tr>
<td></td>
<td>14:48:59</td>
<td>0.25</td>
</tr>
<tr>
<td></td>
<td>15:05:20</td>
<td>0</td>
</tr>
</tbody>
</table>

Based on the reading of the rain intensity sensor shown in Table 2, a value of 94.00 indicates very heavy rain that occurred on Wednesday, August 16, 2023 at 14:31 WIB. Meanwhile, a value of 0.25 indicates light rain that occurred on Friday, August 18, 2023 from 14:19 WIB to 14:48 WIB.

CONCLUSION

Through the implementation of the Internet of Things (IoT), a hardware system has been created for real-time monitoring of chili pepper agricultural land. This helps farmers observe weather conditions, including wind and rain, to improve farming efficiency. IoT-based software solutions also enable access to weather information via smartphones, assisting decision-making in planning farming activities and dealing with dynamic weather changes.

ACKNOWLEDGMENT

We would like to express our gratitude for this opportunity to express our sincere appreciation as the authors of the journal entitled “IoT-Based Rainfall Monitoring System for Chili Farming Land.” The publication of this journal is the result of our hard work and dedication in describing how IoT can improve agricultural efficiency with real-time weather monitoring. We would like to thank everyone who has supported and contributed to this research, and we hope that this journal will be a valuable reference in the development of IoT-based agriculture.

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