IoT-Driven Soil Moisture Monitoring in Organic Rice Cultivation

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Abstract. *This research article explores the Internet of Things (IoT) in organic agriculture, focusing on data monitoring. The IoT devices and connected technologies have created new opportunities for agricultural providers to monitor and gather data across traditional farm settings. This study presents the development of a custom IoT device equipped with various sensors, air temperature, humidity and soil moisture sensors, to continuously monitor hydrology and soil data. Data collected from these devices are securely transmitted to Google sheet file and NETPIE2020 for real-time analysis. The article discusses the technical aspects of the IoT device, the data transmission and storage infrastructure and the implementation algorithms for predictive soil moisture data. Furthermore, the results of a pilot study in which the IoT device was tested on a group of organic agriculture. The study demonstrates the potential of IoT in improving outcomes, reducing time and enhancing the quality of data through continuous remote monitoring. The findings of this research suggest that IoT has the potential to revolutionize the agriculture industry by providing proactive and personalized solutions. The results efficiency evaluation results by 5 experts show that a total mean of 3.86 and a standard deviation of 0.30. Our study optimal soil moisture levels for rice cultivation in Chainat Province, providing guidelines for maintaining these levels to maximize yield. Furthermore, the research extends the data collection period to analyze the impact of temperature and humidity on rice growth, valuable insights into how these environmental factors interact with soil moisture to influence crop health (30-40%). The practical benefits and effectiveness of the IoT system, user-friendly guidelines and tools are developed to support farmers in making data-driven decisions, ensuring successful adoption and utilization of the technology.*

Keywords:

Internet of Things, organic agriculture, soil moisture

1. Introduction

IoT can be used to collect real-time data on a variety of factors that affect rice cultivation, such as water levels, nutrient levels, air temperature, and humidity. This data can be used to develop predictive models that can help farmers make better decisions about irrigation, fertilization, and other crop management practices. IoT can also be used to automate tasks which can save time and cost. Overall, IoT has the potential to help farmers improve the efficiency and sustainability of their organic rice cultivation practices. Here are some specific examples of how IoT can be used to improve organic rice cultivation: Precision irrigation: IoT sensors can be used to monitor soil moisture [1] levels in real time and automatically adjust irrigation systems to ensure that rice plants are getting the right amount of water. This can help to reduce water waste and improve crop yields. Nutrient management: IoT sensors can be used to monitor nutrient levels in the soil and irrigation water. This information can be used to develop customized fertilization plans that ensure that rice plants are getting the nutrients they need without overfertilizing. The IoT sensors can be used to monitor pest populations and environmental conditions that favor pests. This information can be used to develop early warning systems for pest outbreaks and to target pest control measures more effectively.

Overall, IoT has the potential to play a major role in helping Thai farmers to improve the efficiency and sustainability of their organic rice cultivation practices. This could help to increase the competitiveness of Thai organic rice in both domestic and international markets. The potential to revolutionize organic rice cultivation in Thailand [2], the use of IoT technology to collect real-time data on a variety of factors that affect rice cultivation. This data can then be used to develop predictive models that can help farmers make better decisions about irrigation, fertilization, and other crop management practices. For example, IoT sensors can be used to monitor soil moisture levels in real time and automatically adjust irrigation systems to ensure that rice plants are getting the right amount of water. This can help to reduce water waste and improve crop yields [3]. Additionally, IoT sensors can be used to monitor nutrient levels in the soil and irrigation water. This information can be used to develop customized fertilization plans that ensure that rice plants are getting the nutrients they need without overfertilizing. Overall, IoT has the potential to help farmers improve the efficiency and sustainability of their organic rice cultivation practices. This could help to increase the competitiveness of Thai organic rice in both domestic and international markets. Our objected interest in the research team's work on developing a system for predicting climate and other factors for organic rice cultivation. This could be a valuable tool for helping farmers to adapt to the challenges of climate change and to ensure that they are able to produce high quality organic rice even in the face of increasingly unpredictable weather conditions. Our research was about disseminate their findings to farmers and to develop a water management system for organic rice.

2. Theoretical and Related Researches

A. Software development for IoT

The software development life cycle (SDLC) principle applies to IoT research [5]:

1) Research Planning: define the scope, goals and requirements for the IoT research project. Understand the specific agricultural needs, such as soil moisture monitoring, weather forecasting, pest detection, and automated irrigation.

2) Feasibility Analysis: assess the practicality of conducting the proposed IoT research. Identify potential challenges, limitations, and risks. Review existing IoT studies relevant to the project. Assess the availability of sensors, connectivity options (e.g., LoRa, NB-IoT) and budget constraints.

3) System Design: create a plan and architecture for the IoT system. Select hardware components and sensors. Develop data processing algorithms. Design an architecture with soil moisture sensors, weather stations, irrigation control units, a central gateway, and cloud services. The data flow from sensors to the cloud and then to the farmer's mobile app for real-time monitoring and control.

4) Implementation: develop and code the embedded systems to collect sensor data. Establish interfaces and software to manage system data and functions. Integrate components to implement the planned IoT system. Develop firmware for soil moisture sensors to transmit data to the central gateway. Create a cloud-based application to collect, analyze, and store sensor data. Develop a mobile app that allows farmers to monitor field conditions and control irrigation systems.

5) Testing: thoroughly test system functionality, performance, reliability and security. Verify it meets the defined research requirements. Refine the system until requirements are fulfilled. Test soil moisture sensors to ensure they accurately measure and transmit data. Conduct integration testing to ensure data from sensors is correctly processed by the cloud application and displayed on the mobile app. Perform system testing in a test field to validate the entire setup. Gather feedback from farmers to refine the interface and fix any usability issues.

6) Deployment Plan the rollout in stages, starting with a pilot project on a few farms. Gradually expand the deployment based on feedback and performance. Provide training sessions for farmers on how to use the mobile app and interpret the data.

7) Maintenance and Updates: Monitor the performance of the system and address any connectivity issues with sensors. Release software updates to improve data accuracy and add new features like pest detection alerts. Update firmware of sensors and actuators to enhance their reliability and security.

In IoT research [6], the SDLC is critical for ensuring the development of robust, reliable and secure IoT solutions. Researchers need to pay special attention to the unique challenges of IoT, such as data management, connectivity and security. Additionally, staying up to date with the latest IoT research trends and technologies is essential for conducting effective IoT research.

Design: Create the architecture and design for your IoT solution. This includes selecting hardware components, designing data processing algorithms, and planning for scalability and security. Implementation: Develop the IoT system, which involves coding for embedded systems, setting up data collection, and creating the necessary software and interfaces. Testing: Rigorously test the IoT system to ensure that it meets the defined requirements. This may include functional testing, performance testing, and security testing. Deployment: Deploy the IoT solution in a real-world environment. Monitor and finetune the system as needed. Maintenance and Support: Provide ongoing support and maintenance for the IoT system. This includes addressing issues, updating software, and ensuring data security. Documentation: Document the entire SDLC process, including design decisions, code, and testing results.

The application of Internet of Things (IoT) technology in mushroom cultivation houses, focusing on the monitoring and control of temperature and humidity. The IoT control box, a central component of the system, enables semi-automated operation, reducing the need for direct farmer intervention. Farmers can monitor and control the system through a smartphone application, with options for both online and offline control[7].

B. Water management in rice cultivation

There are different methods of growing rice in Thailand. If divided by the nature of water use, it can be divided into 2 types: the method of growing rice using rainwater and another method of using water from surface water sources or irrigation systems. Growing rice in rainfed areas there will be control over the amount of water or water management in the rice fields to be related to the growth period of the rice. Rice farmers in rainfed areas must know and study the climate. In each area, it is grown very well. To manage planting under the very close relationship of soil, water and plants to make rice production successful. Receive production according to the next objective but in some years, farmers face problems with fluctuating conditions of rain, such as too little or too much rain. There is an uneven distribution of rain, it may affect the growth of rice and result in low yields. Even in irrigation areas, in some years there is low water supply. Production of offseason rice in irrigation areas will be affected. It is reported that Thailand currently has rice growing areas. Irrigated rice fields are approximately 15 million rai, but only 1.5 million rai have the potential to receive complete irrigation water and no water shortage problems during the growing season. Therefore, water is an important basic factor for rice production that farmers must have appropriate and efficient water management for rice cultivation. The details of the water management system in the rice field irrigation area are as follows: Water retention in the rice fields throughout the growing season at a depth of 2.5-7.5 centimeters (Shallow continuous flooding) [5].

This type of water retention works well with newly developed rice varieties. The results showed that shallow water retention did not make rice production different from high water retention. During the same irrigation period (85-90 days) and with an efficiency of using 1.02 grams of water per 1 liter of water, water is kept in the fields throughout the growing season at a depth of 15 centimeters (deep continuous flooding). The yield at the deep level is no different from the shallow level of water retention. Sometimes rice production is reduced if the water level is too high for certain rice varieties. Increasing the water level will cause the rice to have taller stems and less tillering. Water use efficiency is approximately 0.95 grams per liter of water and water consumption is higher due to deeper penetration. Lateral seepage is greater than shallow water retention.

Water management using alternating wet and dry (AWD) [3] has the following steps:

1) Prepare the soil for planting rice using the usual method. When rice seeds are sown, drain the water from the rice fields to dry.

2) When the rice is about 10-12 days old, spray herbicides based on the type of weeds that occur. When the weeds have died for 3 days, increase the water level in the rice field by about 3 cm. and keep it for 3 days.

3) Apply fertilizer for the first time. Then maintain the level of flooding on the soil surface, retaining water until the water dries up. If weeds are found, quickly eliminate them again.

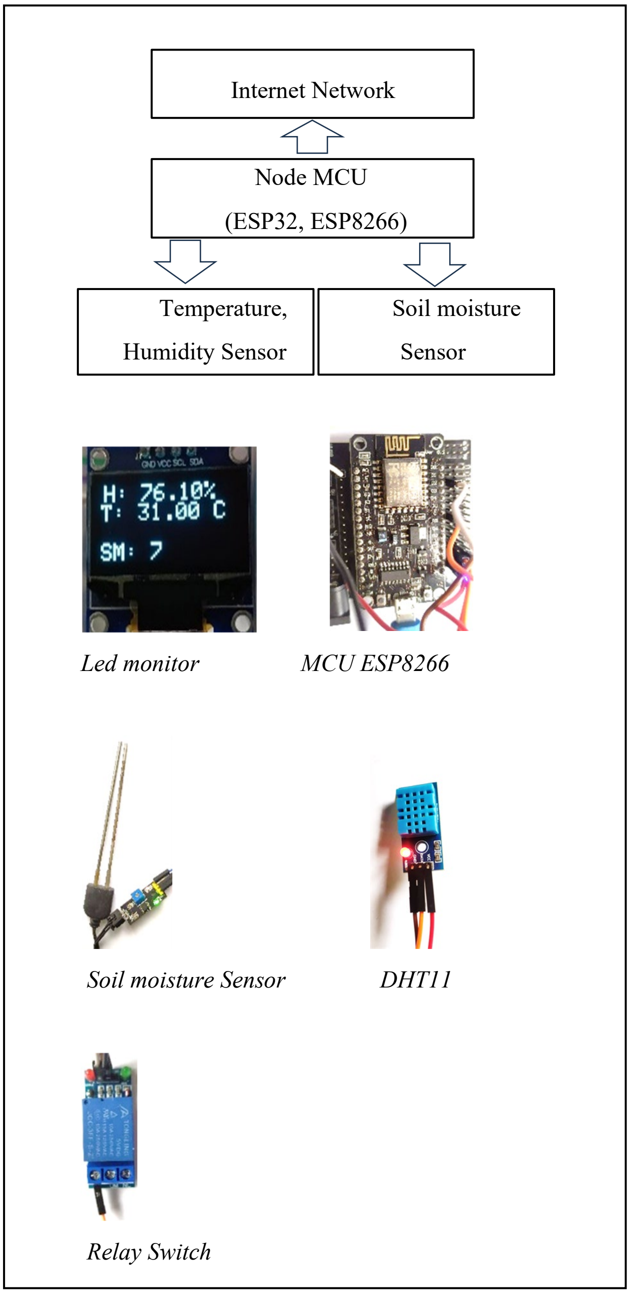

Fig. 1 IoT device for IoT technology soil moisture learning.

4) After about 2 weeks, the water in the rice fields began to dry up. The soil began to crumble. Drain water into the field at a level of 3 - 5 cm. and keep it there until the water dries up. Water alternately between wet and dry until the rice is about 45–50 days old. If weeds are found, they must be eliminated quickly.

5) When the rice is in the peak tillering stage (45-50 days old), increase the water level in the rice fields by 5 cm. and keep it for 3 days until the rice begins to form flower buds (50-55 days old).

6) Apply fertilizer a second time after 7 days, increase the water level by 10 cm. Maintain the water level until the rice has flowered and the starch in the seeds has begun to harden (15-20 days after the rice has flowered).

7) After the rice has flowered for 20 days, drain the water from the field to dry to speed up maturation.

Rotational irrigation is a method of watering rice on a rotating basis, alternating between periods of standing water and dry water. There is no need to keep the water locked all the time. Suitable for areas where there is little water. and want to conserve water for use in other activities in the fields and throughout the season, water use is relatively low, 60-70 centimeters/growing season [8], and water use efficiency is high. The yield obtained is no different from water retention throughout the growing season. However, this method still has many limitations. Because there is a severe weed problem and experience in soil, fertilizer and weed management is required in special cases. Draining water from rice fields in the middle of the growing season. This type of water management helps keep rice field soil in an oxidized state for the benefit of releasing toxins. and carbon dioxide that occurs in the rice field is removed and has the effect of causing some nutrients to be oxidized to benefit the growth of rice. and is commonly practiced in fields in cold regions where the rate of organic matter decomposition is low [9].

Bophimai et.al [10] development of organic intelligent technology system, the development and evaluation of a smart technology system for organic farming. The objectives included creating the system, assessing its efficiency and evaluating its quality. The technology integrates IoT (Internet of Things) with a ready-made application called the blynk application, smartphone connectivity and various sensor devices such as temperature and soil moisture sensors. Solar energy powers the system. After development, the system was tested, showing control over sensor operations and was evaluated positively by experts. Results indicated high-quality performance with an average was 4.79 out of 5 and standard deviation was 0.42.

A. Bunchuay and S. Chaephan [11] presented research on white rice. An outstanding strain of rainfed rice in Chainat Province, “Khao Jek” is a good strain of native rice that is widely grown in Den Yai Subdistrict. and Prai Nokyung Subdistrict, Hankha District, it is quality rice. Chainat Rice Research Center The afore-mentioned rice varieties were collected in 2004, selected pure varieties, studied the varieties, compared yields within stations and between stations, and tested yield stability. Testing outstanding strains, research results found that it has the characteristics of rice that is sensitive to photoperiod, light age, green stems and leaves, hard stems, does not fall easily, moderately dense ears, yields 528 kilograms per rai. Caution is that it is susceptible to dry leaf edge disease. Relatively susceptible to blight. and is not resistant to BPH. P. Suanpleng and P. Chaemchan[12] presented research on A Smart Farm Prototype with an Internet of Things (IoT) Case Study: Thailand. They designed a prototype smart farm system that utilizes sensors to measure temperature and humidity, leveraging the Internet of Things (IoT) technology. The system incorporates an automated water control system using IoT devices. The hardware component of the system use a Raspberry Pi board installed in a control box, which collects data from the field using DHT22 sensors. These sensors are employed to monitor temperature and humidity levels. The environmental data from the plants is transmitted by the control unit within the control box. Additionally, the system incorporates a web application that has been designed and implemented to collect and display real-time data for users. The web application serves as a platform for users to access and monitor the relevant data from the smart farm system. The automatic water control system is a key feature of the smart farm prototype. The research findings indicate that the system offers significant benefits to farmers, enabling them to increase crop yields while simultaneously reducing costs through the adoption of this technology.

3. Research Method

This research used a participatory action research process involving local researchers. It is research that focuses on farmers using research as a tool based on research concepts and methods for the local area. The research is research that focuses on the participation process of farmers in the local community. To understand and find options to solve problems in every issue. Local researchers will be involved in every step of the process. Starting from analysis to determine research problems/ questions, reviewing knowledge. Research design and planning of research operations data collection and data analysis real practice trials to find ways to solve problems during the process. The results are evaluated and summarized by bringing results and conclusions from research into options for solving problems in the area. This can be summarized as the research method as follows.

(1) Review of research/document examination related to water management methods. Water use by cultivated plants use of agricultural technology farmer's way of life gather basic information in Chainat Province.

(2) Analysis of data inspection results by summarizing factors affecting water management in Chainat Province and the use of technology to reduce costs in growing rice.

(3) Organize a farmer group meeting people interested in agricultural careers and experts join the project [13],[14].

(4) Designing learning tools for IoT technology systems for use in rice cultivation and collecting additional information.

(5) Organizing usage workshops for farmers, students and those interested in rice cultivation, government personnel gather various suggestions.

(6) Summarize results and publish manuals and learning resources to develop further.

(7) Write reports and summarize results. Learning set Internet technology system that integrates small digital devices consists of a sensor program to measure humidity and air temperature (DHT11, DHT22) and sensors for

measuring soil moisture and Arduino processing equipment or node MCU equipment to distribute electricity. Development of computer programs to read the values of each type of sensor data. The obtained values are recorded through memory or can send data values to the cloud, through internet signal transmission equipment. Readable digital data can be used to store information in databases shown in Fig. 2 Including being able to use it to quickly analyze data. This will allow agriculture to use data to help make decisions and accuracy. The information uses to design a smart farm system using temperature sensors and humidity in the air and soil moisture values. The algorithm for anomaly detection analysis to moisture data collection in soil, because the experiments yielded very high or very low values compared to normal. Therefore, the researchers looked into this issue and analyzed the causes behind these abnormal values. In essence, the researchers used anomaly detection techniques to analyze the unusual moisture sensor readings in the soil experiments, in order to understand the reasons for those outliers.

4. Results and Discussion

From the design of the draft learning kit and a meeting to explain the research project and listen to opinions from experts and farmers in the area and related agencies. The research team has an approach to develop a learning kit for the Internet technology system that integrates small digital devices for organic rice cultivation. The details are as follows.

Table 1 Data dictionary structure design

Table Name	Soilmoisture_Data		
Description	Soilmoisture data in organic rice cultivation		
Field Name	Description	Data Type	Field Size
Id	Number id	Integer	5
Date	Date of record	Date	-
Time	Time of record	Time	-
Temperature	Air Temperature	Float	20
Humidity	Humidity	Float	20
Soil Moisture	Soil Moisture	Float	20

Learning set for measuring air temperature and air humidity measurement, consisting of connecting the DHT22 sensor device, the NodeMCU ESP8266 device, and the power supply. Explaining the basic command set verifying the operation of sensor equipment reading and displaying air temperature measurement results and measuring air humidity. The soil moisture sensor module, verifying the operation of sensor equipment Explaining the basic command set Reading and displaying soil moisture values.

The results section presents the efficiency evaluation results by 5 experts shown that in table 1. Results from performance evaluation by experts the learning set on internet technology integrates small digital devices for organic rice cultivation. It was found that the content of the learning set topics related to content that are interesting to learn on your own, with an average of 4.05, followed by content on learning set steps. It was accurate with an average of 3.68 and the content was consistent with the objective with an average of 3.36. As for the design of the learning kit, it was found that the design of the learning kit was appropriate for the sample group with an average of 3.88, followed by the design of the learning kit. Easy to understand, average 3.86, and the design of the learning kit is interesting, average 3.85, terms of utilization it was found that the learning kit is useful for those interested in organic agriculture, average 4.55, followed by the learning kit. Learn to create understanding in the process of learning internet technology systems, average 3.85 and last the learning set is interesting in use, with an average of 3.70, respectively. From the evaluation, all 3 aspects according to the questions were at the highest level. Obtained a total mean of 3.86 and a standard deviation of 0.30 from using a learning set of integrated internet technology of small digital devices for organic rice cultivation.

Table 2 Examples Data Collected in Google Sheet

Date	Time	Soil Moisture (%)	Humidity Air (%)	Temperature (ºC)
7/23/2022	18:15:03	37.79	65	32
7/23/2022	19:18:53	33.30	60	31
7/23/2022	19:35:35	32.13	61	30
7/23/2022	20:08:04	32.23	62	30
7/23/2022	20:40:35	29.69	62	30
7/23/2022	20:57:22	29.69	62	30
7/23/2022	21:45:30	30.96	63	30
7/23/2022	22:33:39	30.37	64	30
7/23/2022	22:50:27	32.42	65	30
7/23/2022	23:07:10	29.88	65	30
7/23/2022	23:39:35	30.76	65	29
7/23/2022	23:56:17	30.57	66	29
7/24/2022	0:12:59	29.98	66	29
7/24/2022	0:45:28	31.54	66	29
7/24/2022	1:17:53	31.05	67	29
7/24/2022	1:34:36	29.59	68	28
7/24/2022	2:07:02	30.76	69	28
7/24/2022	2:23:47	29.49	69	28
7/24/2022	2:40:29	29.49	69	28

Come experiment with the organic farming group to see the methods, steps, and equipment used in conjunction with organic rice growing methods. It can be used and has a method that is not complicated, along with someone who can advise on how to use it in a targeted way, such as detecting ground moisture in rice fields that has decreased to the level of water shortage in front of the dry soil. The soil begins to change color. There are more weeds growing.

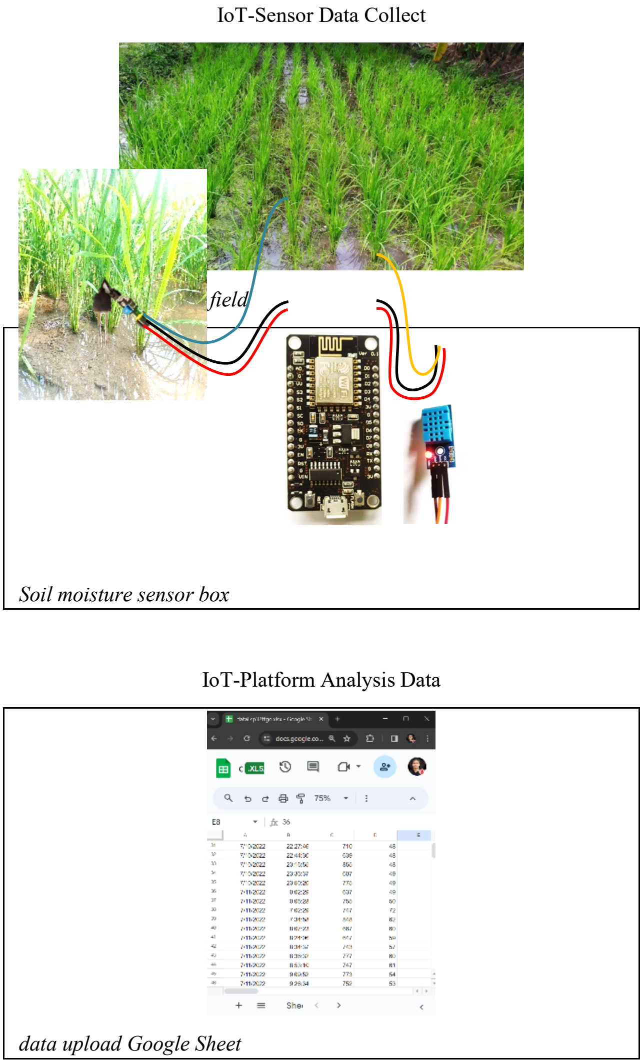

Fig. 2 The system architecture diagram and measuring soil moisture with IoT device.

There is a mobile warning system that can be used as a smartphone. It will allow farmers to be able to command the water pump through their smartphones to pump water into their fields with real efficiency. By studying the learning kit to understand the principles and methods. Therefore, the results from the evaluation from 5 experts were used as guidelines for creating a learning kit to benefit the organic rice growing group and researchers. Working steps of the C language program for temperature and humidity sensors in the air. Start the operation of the NodeMCU ESP8266 processor, read the Wi-Fi signal through the internet connection and check the operation. When passed, proceed to the next step. Read data from DHT11 sensor and check operation. The next step is to save the data in the Google Sheet database and check. The final step, use the flow chart to create a C language program shown in Fig. 3.

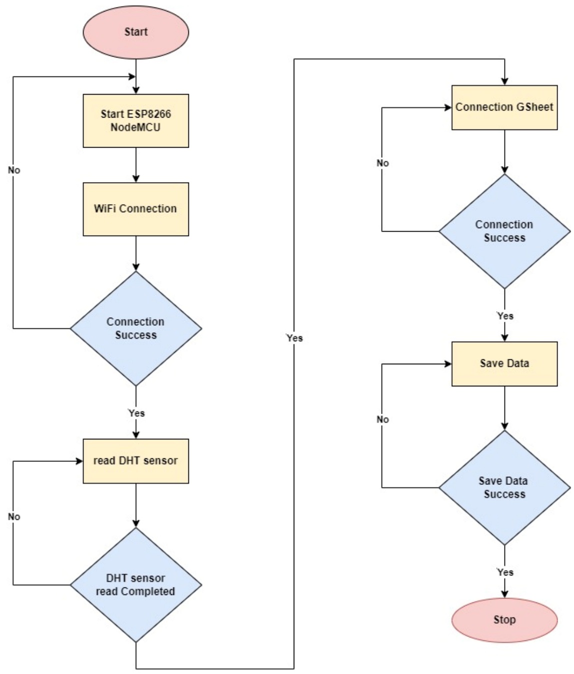

Fig. 3 IoT diagram for connection and collect data .

The examples data are shown in Table 2, provided data appears to be a timeseries dataset: DateTime: this column represents the date and time of the recorded data, Soil moisture: this column indicates the soil humidity, presumably measured as a percentage, Humidity air: this column represents the air humidity, also likely measured as a percentage, Temperature: this column indicates the air temperature, measured in degrees Celsius. Each row in the dataset represents a specific timestamp where measurements were taken for the corresponding environmental variables. Here's an example interpretation of the first row: Date: July 23, 2022, Time: 18:15:03, Soil Moisture: 37.79%, Air Humidity: 65%, Air Temperature: 32°C Similarly, the subsequent rows provide data for different timestamps, allowing you to observe how these environmental variables change over time. This type of data is commonly collected in environmental monitoring, agriculture and climate studies to understand patterns and trends. The ideal humidity for rice is around 20-30%. In the winter season the humidity was about 20-25% and the rainy season was about 25-30% shown in Fig. 4. However, farmers have accurate tools or measurements, they will be able to take care of water management more efficiently. There is a reference data set for soil moisture in areas where organic rice is grown, along with observations of rice growth in nearby areas. The data can be used as a reference source using the designed IoT tool set. It is inexpensive and

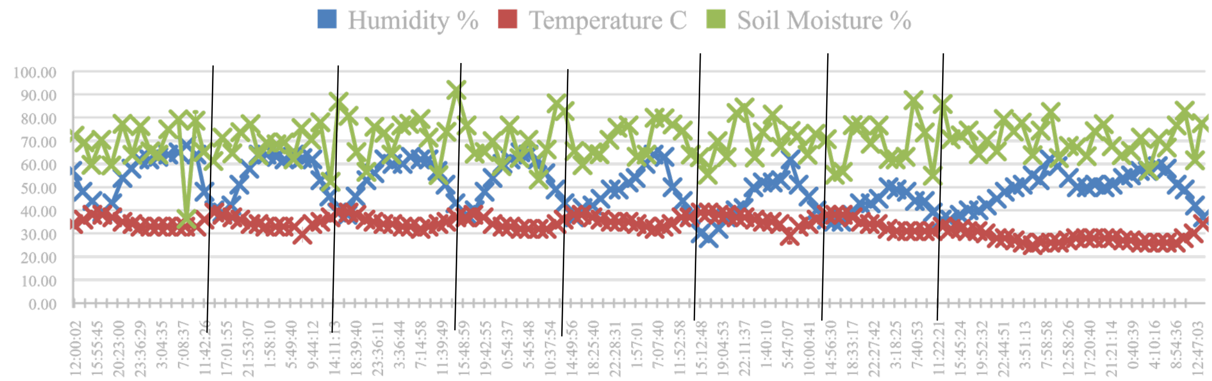

Fig. 4 IoT data from soil moisture sensor and temperature humidity sensor

convenient to use and those who understand how to connect circuits correctly.

The experiment that collected soil moisture data from a sample rice field, a prediction model was created using the relationships of the data collected from sensors measuring temperature, relative humidity and soil moisture shown in figure 4. Algorithms were used to process the data, reducing variance and increasing accuracy[15]. The data was divided into groups to achieve higher accuracy showed that equation 1. This allowed the group of organic rice farmers to further apply the method by using an IoT device set to record soil moisture data in 2 areas of their fields. Udom Dokdaeng [14] is the head of the Don U-lok organic farmer group in Den Yai subdistrict, Hanka district, Chai Nat province. The following suggestions: using IoT to record soil moisture data in the fields allows using the data to plan for the next planting season. The IoT equipment used is inexpensive and predicting soil moisture and applying technology to organic farming will result in easier data collection tools. Farmers can more conveniently follow organic farming requirements with data support decision.

$$\theta_t = f(\theta_{t-1}, P_t, E_t, T_t, other) \quad (1)$$

where:

θ_t is the soil moisture that needs to be predicted at the time t

θ_{t-1} is the soil moisture measured at the time t−1

P_t is the amount of rainfall at the time t

E_t is the evaporation of water in the time t

T_t is the temperature at the time t

other factors include relative humidity, irrigation, cooling, etc.

The temperature data set and humidity data used to predict soil moisture data; the results obtained do not have a linear relationship. The regression algorithm r^2 coefficient is very small and find variable to a relationship. The results are not arranged linearly. Other features may need to be added such as rainfall, evaporation and wind speed daily data.

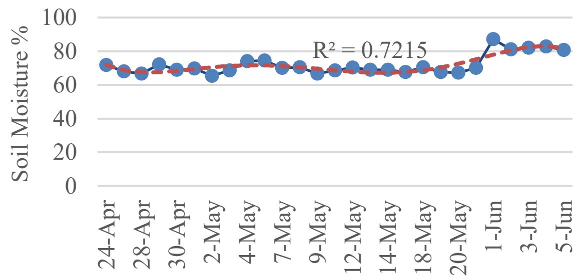

Fig. 5 Soil moisture sensor measurement @ 12.00 am.

In this research, daily soil moisture measurements taken at 12:00 am. were used as the representative data points. These measurements were utilized to develop trend equations for forecasting purposes. The analysis focused on the period from April 2022 to June 2022. The resulting trend equation demonstrated a coefficient of determination (r^2 value) of 0.7125, indicating a moderately strong fit between the model and the observed data.

A real-time soil moisture data from an IoT system could be useful for organic rice cultivation:

1) Optimize irrigation - By tracking soil moisture levels, farmers can determine the exact timing and water needs for irrigation, avoiding over or underwatering. This promotes growth while conserving water.

2) Inform fertilizer application - Moisture data helps determine if the soil environment is conducive for nutrient uptake. Farmers can apply fertilizers only when conditions allow it to be utilized by the plants.

3) Monitor crop health - unexpected moisture changes can indicate underlying issues like diseases, soil quality problems etc. Early notification allows for timely corrective actions.

4) Manage environmental shocks - Realtime data enables early diagnosis of droughts or floods, allowing mitigation steps to prevent crop loss.

5) Enhance sustainability - Efficient water usage and avoidance of excess fertilizer contributes to environmental sustainability goals of organic farming.

6) Improve yields - Judicious irrigation and nutrients based on soil moisture ultimately promotes better plant health and higher organic rice yields.

7) Facilitate data-driven decisions - Quantitative moisture data allows for objective, evidence-based farming strategy instead of qualitative guesswork. IoT systems (accurate and live soil moisture insights) can help organic rice farmers make informed decisions that benefit productivity sustainability and health of the agroecosystem. The data serves as a valuable input for precision agriculture.

5. Conclusion

The collection of IoT data on rice cultivation throughout the season, planting planning. The knowledge in organic rice production of farmer groups, various environmental factors that affect productivity. Using agriculture technology and keeping data in digital form to be effective example minimum soil moisture to influence crop health was 30-40%. The results efficiency evaluation of IoT learning Kit show that a total mean of 3.86 and a standard deviation of 0.30. The record data prediction and farmer use to decision making support for next season rice cultivation planning. The group that produces organic rice has developed with support from government agencies such as subdistrict agriculture, Rice Research Center. To improve rice to have more area for growing organic rice. Creating a boundary by planting plants to protect the chemicals used from other areas. Including making water channels around the rice fields and water management using alternating wet and dry. Using soil moisture data collected compost that is beneficial to the area sufficient amount of water for growing rice and receiving accurate information farmers who want to farm organic rice must have education and learn from both government and private agencies. This will result in organic farming being successful and sustainable.

The future works are expanding the study with a larger sample size or additional test groups, Applying the methods or technologies to new areas or problems, Refining the data analysis techniques or theoretical models to prediction data.

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