Application of Internet of Things (IoT) Technology to KWT "Sido Makmur" Oyster Mushroom Cultivation

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ABSTRACT

Ngaran Hamlet, an area in Gilangharjo Village, Pandak District, Bantul Regency, DIY, has a Women Farmers Group (KWT), "Sido Makmur," which is engaged in oyster mushroom cultivation. One of the challenges KWT "Sido Makmur" faces is the fluctuation and instability of oyster mushroom production due to environmental conditions around the mushroom barn, which are not always ideal. To overcome this, the Community Service Team from Universitas Muhammadiyah Yogyakarta (UMY), in collaboration with Singapore Polytechnic (SP), carried out Community Service activities under the Community Partnership (PKM) scheme. This service aims to assist KWT "Sido Makmur" in facing the challenges of oyster mushroom production by designing and implementing Appropriate Technology in the form of a temperature and humidity monitoring system in mushroom barns based on the Internet of Things (IoT). The service team's programs and activities include planning, designing, implementing, testing, and analyzing the IoT technology-based mushroom monitoring system for temperature and humidity. This system allows oyster mushroom farmers in Ngaran Hamlet to monitor the condition of the mushroom coop in real-time and remotely via the IoT platform to increase the productivity of oyster mushrooms optimally. The results of the implementation and testing of the system show that the monitoring tool for temperature and humidity in the IoT-based mushroom barn has been proven to function properly in accordance with the design planning and expectations of oyster mushroom farmers in Ngaran Hamlet.
Keywords: community service, temperature and humidity monitoring system, internet of things, oyster mushrooms

INTRODUCTION

The cultivation of oyster mushrooms is currently quite popular in rural and urban communities, both on a small, medium and industrial scale. In small-scale industry, it is very easy to do because it does not require a lot of capital and equipment. The capital is mostly needed for a place for mushroom cultivation, better known as a mushroom house and a place for mushroom seeds to grow, called a baglog. In the process of cultivating oyster mushrooms, regular maintenance is needed so that the mushrooms can develop properly. Other important factors such as temperature, humidity, light, pH, growing media, and aeration are indicators that can affect the growth process of oyster mushrooms (Dewi, Nirwana and Saputra, 2018). In areas with average daily conditions of hot temperatures, the risk of failure is quite high compared to areas with cold temperatures. Oyster mushrooms, like mushrooms in general, can grow and develop well in areas with cold and humid temperatures. For areas that are too hot and too dry, more frequent maintenance is needed so that the oyster mushrooms can develop properly, such as sprinkling water on the Kumbung floor so that it can maintain temperature and humidity inside the kumbung during the oyster mushroom cultivation process (Anggi & Nurwijayanto, 2016). In the oyster mushroom cultivation process, ideal temperature and humidity conditions are needed in the mushroom house to obtain optimal growth of the mushroom body. In the fruiting body formation phase, it requires an air temperature between 26oC - 29oC with humidity of 70%-90% RH (Rebiyanto & Rofii, 2010) (Jumran, 2010) (Yamauchi et al, 2019).

In the cultivation of oyster mushrooms on a small scale, there are obstacles experienced by oyster mushroom farmers in terms of real-time monitoring of temperature and humidity inside the mushroom barn which needs to be done by mushroom farmers so that the harvest can be maximized. In addition, uncertain weather conditions and conditions such as those experienced in various regions in Indonesia can also affect the yield of oyster mushroom cultivation. Currently, in the process of oyster mushroom cultivation in general, to deal with changes in temperature and humidity in the mushroom house, they still use the manual method by spraying water slowly from the top of the baglog and utilizing the soil moisture used as the bed for the houseplant. Mushroom farmers usually only estimate the temperature and humidity in mushroom sheds and do not use definite measuring instruments (Sofyan et al., 2020). The conditions and obstacles mentioned above were also experienced by the Women Farmer Group "Sido Makmur" located in Pandak District, Bantul Regency, DIY Province, as the location for the community partnership service program carried out by the author.

With current technological developments, the ease in the oyster mushroom cultivation process can be applied, especially in small-scale cultivation, for example, in real-time monitoring of temperature and humidity in kumbung, to increase efficiency and save time for mushroom farmers. One of the technological developments for monitoring temperature and humidity today can be done automatically using the ATmega16 microcontroller or Arduino Uno (Suryowinoto, Hamid, & Lenoyo, 2016). In addition, there is research that designs control systems and monitors temperature and humidity based on the Internet of Things (IoT) using the ESP8266 wireless module connected to a web server as data storage (Kurnia Sari, Hasan, Devionita, 2018). In terms of automatic decision-making, the system can use the on-off control method or PID control (Afandi, 2016) (Tri Surya, 2018), as well as fuzzy control (Dan et al., 2016). IoT implementation in smart farming has also been carried out (Muangprathub, 2019). The design of monitoring or monitoring systems carried out in previous research has implemented IoT technology as found in (Octavia & Kurniawan, 2018) (Chanim et al, 2020) and also utilizes the Blynk application (Ahkam Sougy, 2018).

In this program, the service team plans and implements appropriate technology by designing a temperature and humidity monitoring system implemented in an oyster mushroom cultivation barn based on Internet of Things (IoT) technology using the Arduino Mega microcontroller. This system allows users to monitor real-time temperature and humidity conditions in the mushroom house from anywhere and at any time. The partner of this community service program is the Women Farmers Group (KWT) "Sido Makmur," located in Ngaran Hamlet, Gilangharjo Village, Pandak District, Bantul Regency, Yogyakarta Special Province. Implementing this service activity also involves collaboration and cooperation with Singapore Polytechnic (SP) to develop and implement appropriate technology used by KWT service partners "Sido Makmur".

Figure 1. KWT "Sido Makmur"

Figure 2. Condition of Mushroom House in KWT "Sido Makmur"

METHODS

In this section, the methods and steps of community service planning and implementation of appropriate technology are described in the form of a temperature and humidity monitoring system for oyster mushroom cultivation based on Internet of Things (IoT) technology at service partner locations. The main stages and steps in implementing appropriate technology that the service team has carried out include: identifying the main problems, designing system designs according to user needs, designing hardware and software according to the system design that has been made, implementing the system in accordance with the design and specifications of the planned device, conducting testing of the entire system, and analyzing the results of system testing. The main stages and steps were a series of processes to ensure the system worked well. The design of appropriate technology for the temperature and humidity monitoring system in this service program is shown in Flowchart 3 below.

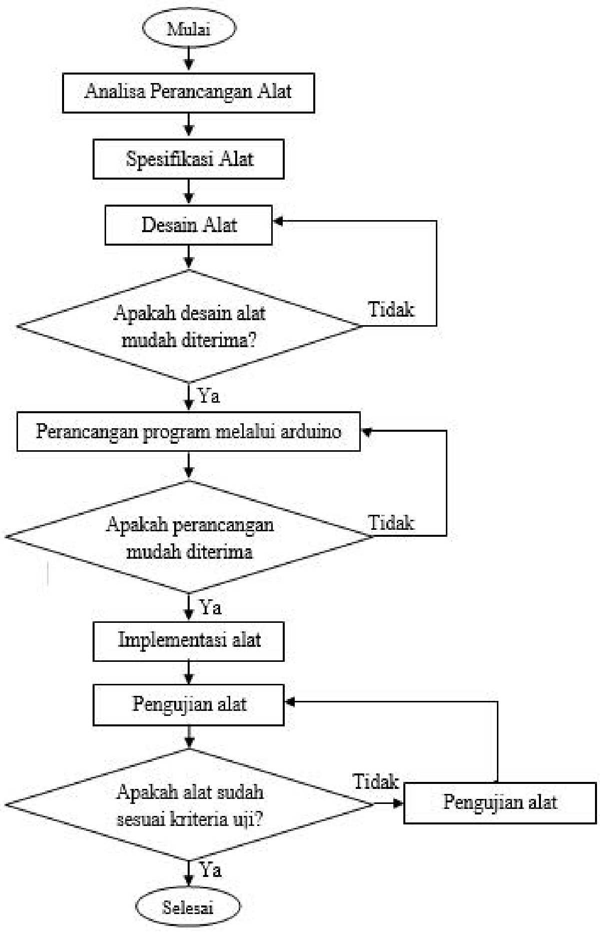

Figure 3. Flowchart of Making a Temperature and Humidity Monitoring System

In the process of designing appropriate technology for an IoT-based mushroom monitoring system for temperature and humidity in this community service activity, the service team designed both hardware and software systems, which are explained as follows:

1. **Specifications for Temperature Monitoring Systems Based on Internet of Things (IoT)**

a) Hardwares

1) Bosch XDK Sensor
The XDK sensor will read the required parameters in the form of temperature and humidity in the mushroom house.

2) Arduino Mega
Arduino Mega functions as a data processor from sensors and as a gateway that connects the XDK to other electronic components, such as the LCD layer and the GSM module (SIM800H Module) for the data download process.

3) GPRS Shield
The GPRS Shield gives access to the internet network via a connection based on 2G cellular wireless technology. The internet network will activate the data that has been stored so that it can be downloaded or sent online to the server. GPRS Shield has an antenna that functions to receive and transmit data.

4) LCD
The LCD used in this system is a 16 X 2 type which will display the temperature and humidity parameter values in the mushroom house.

b) Software

1) Arduino
The system starts working after the hardware or hardware is activated by connecting the device to the power supply. Then the Arduino microcontroller as the sensor controller and data processor will also activate the SIM800H sensors and modules in the system. When the XDK sensor is active, it will carry out its duties to read the temperature and humidity in the mushroom house. Simultaneously the SIM800H module will be active and send directly the data results that have been read by the sensor to the server as data storage. Data entered into the server will be stored automatically in the database server. The following is a flowchart of the hardware working mechanism of appropriate technology for an IoT-based mushroom house temperature and humidity monitoring system.

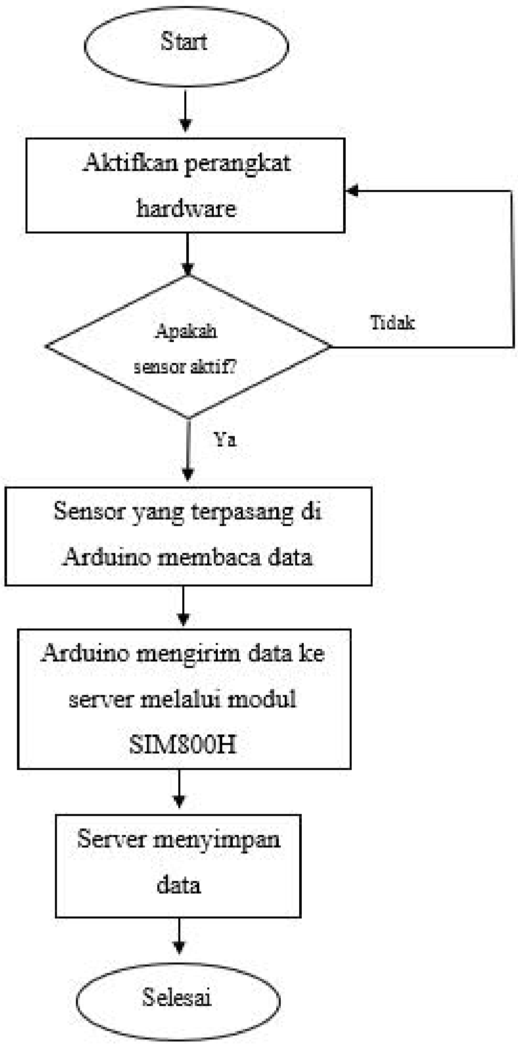

Figure 4. **System Mechanism Flowchart**

2) Android Studio

In the implementation of appropriate technology for monitoring the temperature and humidity of the IoT-based mushroom house, there is an Android-based application software program as an interface to display sensor measurement data to users of oyster mushroom farmers through an Android smartphone application that can be accessed by users in real time anywhere. When running the program in the Android Studio software, the system will request data from the server, which then the data will be directly sent by the server to the Android application in real-time and the value data from temperature and humidity sensor measurements will be displayed in the application.

Figure 5. **System Mechanism Flowchart in Android Studio**

2. Overall Design of Internet of Things (IoT) Based Temperature and Humidity Monitoring System

Figure 5 below shows a schematic diagram of the device and wiring between components in the implementation of appropriate technology for an IoT-based mushroom house temperature and humidity monitoring system called “Shroom Sense”. Arduino Mega is connected to the XDK sensor, which will detect the parameter values for measuring temperature and humidity in the mushroom barn. Kumbung mushroom is declared less humid when the humidity is less than 70% RH. The 16 X 2 LCD component installed on the front side of the device will display the output value of the measurement results of temperature and humidity in the fungus mushroom room. Fan DC Motor in the form of a fan will turn on simultaneously when the power is turned on to stabilize the component temperature to prevent overheating.

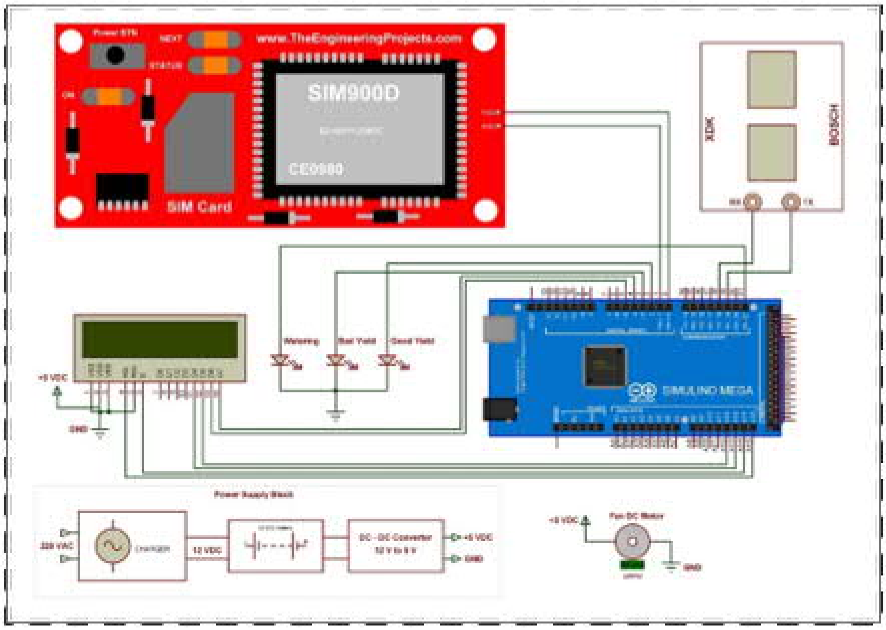

Figure 6. **Schematic Hardware Diagram "Shroom Sense"**

Table 1. **Tool Description**

Temperature limit	24-34∘C
Relative humidity limit	75-90%
Weight	6.5kg
Volume	300mm x 180mm x 300mm
Power Supply	220V AC
Lead Acid Battery	12V, 6.0Ah
Backup Power Source (UPS)	220V AC input, 12V DC output
SIM Card support	2G network
LCD	16x2 LCD shield
Buttons	Colored LED buttons (Blue, Red, Green)

The Lead Acid Battery and UPS convert 220V AC voltage to 12V DC to provide sufficient power. A DC-to-DC converter from 12V to 5V is used to change the voltage of a component that requires a voltage of 5V to operate. Meanwhile, the backup battery (UPS) will be used when the main battery runs out. The backup battery will provide power for a maximum of 2 hours before completely turning off.

Table 2. **Tool Components Power Requirements**

Components	Powers
XDK	5V
Arduino Mega	7-12V
GPRS Shield	6-12V
Fan	12V
Buttons	5V
LCD Screen	5V

The hardware device initialization process includes connecting the device to an AC voltage source, then pressing the on/off button to run the system. Users should pay attention to the blue, green and red LED lights on the front as a sign that the device is on. On the front of the "Shroom Sense" device, there is an LCD that will display the words "**SP&UMY Shroom Sense**" in the initialization process of the device as a system identity displayed on the LCD screen.

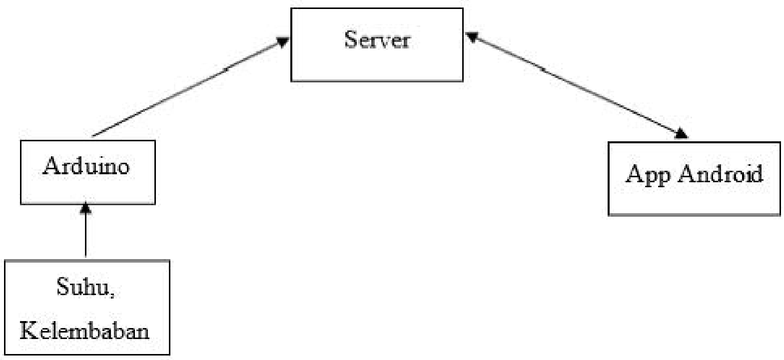

Figure 7. Data Communication Mechanism Design

The data is in the form of temperature and humidity parameter values originating from the XDK sensor. Then the data is sent by the sensor and processed by Arduino. The Arduino output results in the form of temperature and humidity data on the mushroom bed will then be sent to the database server, and the server will store the data. The data stored in the database server will then be called up by the "Jamurku" android application to display real-time temperature and humidity sensor readings on the "Jamurku" android application user's smartphone.

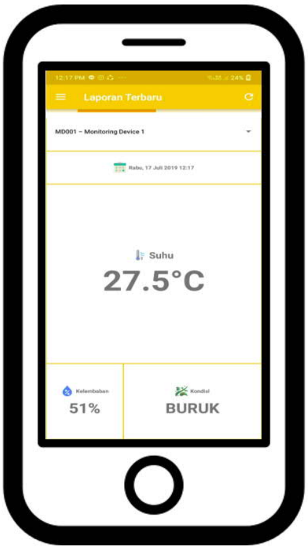

Figure 1. Application Home Display

Figure 2. Menu Display

Figure 3. Monthly Report Display

3. Testing of the Temperature and Humidity Monitoring System in the Oyster Mushroom Based on the Internet of Things (IoT)

This testing phase needs to be carried out before the system is implemented in the field. This is necessary to ensure whether the system is running as expected and to find out the constraints and problems that may occur when operating the "Shroom Sense" device by the user. This testing process is carried out by testing the "Shroom Sense" hardware and software in the form of an Android application called "Jamurku" separately and testing the temperature and humidity monitoring system. The IoT-based temperature and humidity monitoring system was tested for three days from August 19 - 21, 2022, in a closed room.

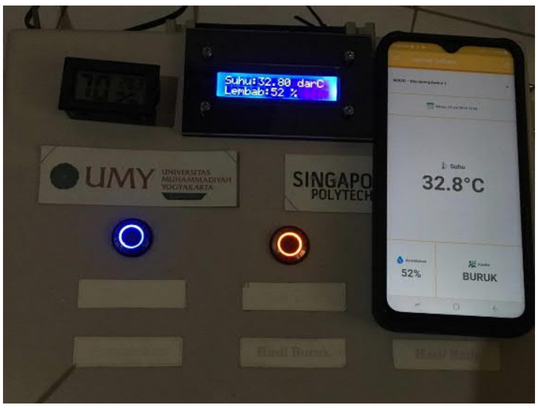

Figure 11. Hardware and Software System Trial

RESULTS AND DISCUSSIONS

This section describes the results of implementing community service planning and implementing appropriate technology in the form of a temperature and humidity monitoring system for oyster mushroom cultivation based on Internet of Things (IoT) technology for service target partners that the service team had carried out.

In the service process, implementation of appropriate technology at the Kumbung Mushroom Mitra location was carried out in several stages: identifying the problems, designing a system according to user needs, designing hardware and software according to system design, implementing the system according to the design, applying device specifications that have been planned, testing system, and analyzing the results of tests. The design stages of the system design have been explained in detail in the previous section.

The next stage that was carried out by the service team after carrying out the implementation and application stages of hardware and software design was to carry out the testing process of the temperature and humidity monitoring system based on Internet of Things (IoT) technology. The testing process is carried out with two scenarios, namely, testing the system in the room and testing the system in a mushroom cellar. The following will describe the system testing process using these two scenarios.

1. Testing the Internet of Things (IoT) Based Temperature and Humidity Monitoring System Indoor

Testing this system was carried out in a closed room and carried out for three days (August 19-21, 2022), with each test lasting 10 minutes. The results of measurements of temperature and humidity produced by the room thermometer and hygrometer are compared with the results of measurements of the temperature and humidity sensors from the "Shroom Sense" device that has been made. In addition, data on the results of temperature and humidity values sent by the server and displayed on the "Jamurku" Android smartphone application in real time are used as comparative data from the two measurement results mentioned above. Detailed test results data can be observed in Table 3, Table 4, and Table 5 below.

Table 3. First Day Testing

Day/Date	Time	Temperature (◦C)			Error	Humidity (%)			Error (%)
		TR*	SS*	JK*	(%)	TR*	SS*	JK*	
Friday, August 19, 2022 (Morning)	06.01	24.1	26.2	26.2	8	74	61	61	21.3
	06.10	23.9	26.9	26.9	11.1	77	62	62	24.2
	06.20	23.7	25.2	25.2	5.9	78	63	63	23.8
	06.30	23.7	25	25	5.4	78	64	64	21.9
Friday, August 19, 2022 (Afternoon)	13.58	28.8	32.6	32.6	11.6	64	49	49	30.6
	14.08	28.7	32.1	32.1	10.5	63	48	48	31.2
	14.18	28.5	32.4	32.4	12	63	47	47	34
	14.28	28.5	32.9	32.9	13.3	63	47	47	34
Friday, August 19, 2022 (Evening)	19.47	25.2	29	29	13.1	74	55	55	34.5
	19.56	25.2	29.1	29.1	13.4	74	55	55	34.5
	20.07	25.1	28.4	28.4	11.6	75	56	56	34
Average		25.9	29	29	10.5	71	55	55	29.4

Table 4. Second Day Testing

Day/Date	Time	Temperature (◦C)			Error	Humidity (%)			Error (%)
		TR*	SS*	JK*	(%)	TR*	SS*	JK*	
Saturday, August 20, 2022 (Morning)	06.06	23.3	25.2	25.2	7.5	79	63	63	25.4
	06.10	23.3	25.2	25.2	7.5	79	63	63	25.4
	06.20	23	25.6	25.6	10.1	79	62	62	27.4
	06.30	23	25.3	25.3	9	79	62	62	27.4
Saturday, August 20, 2022 (Afternoon)	12.03	28.1	29.8	29.8	5.7	62	51	51	21.6
	12.15	28	30.4	30.4	7.9	62	50	50	24
	12.30	27.9	30	30	7	62	52	52	19.2
	12.41	28	30.5	30.5	8.2	62	52	52	19.2
Saturday, August 20, 2022 (Evening)	20.23	25	27.5	27.5	9	75	60	60	25
	20.26	25.2	27.6	27.6	8.7	77	60	60	28.3
	21.25	24.7	26.8	26.8	7.8	76	61	61	24.6
Average		25.4	27.6	27.6	8	72	58	58	24.3

Table 5. Third Day Testing

Day/Date	Time	Temperature (◦C)			Error	Humidity (%)			Error (%)
		TR*	SS*	JK*	(%)	TR*	SS*	JK*	
Sunday, August 21, 2022 (Morning)	07.15	23.5	25.9	25.9	9.3	78	63	63	23.8
	07.25	23.2	26.1	26.1	11.1	79	62	62	27.4
	07.35	23.2	26.2	26.2	11.5	79	62	62	27.4
	07.45	23.3	26.9	26.9	13.4	79	61	61	29.5
Sunday, August 21, 2022 (Afternoon)	11.28	27.9	29.4	29.4	5.1	67	56	56	19.6
	13.08	28.5	30.3	30.3	5.9	66	55	55	20
	13.20	28.3	30.6	30.6	7.5	66	55	55	20
	13.30	28.3	30.8	30.8	8.1	66	54	54	22.2
Sunday, August 21, 2022 (Evening)	18.40	26.5	30.5	30.5	13.1	69	53	53	30.2
	18.56	26.3	30	30	12.3	70	54	54	29.6
	19.11	26.2	29	29	9.6	71	55	55	29.1
Average		25.9	28.7	28.7	9.7	72	57	57	25.3

*Description:
TR = Room Thermometer Measurement Results
SS = "Shroom Sense" Device Measurement Results
JK = Results displayed on the "Jamurku" Application

From the results of three days of tests, an average error value of 7.8-10.5% was obtained for the temperature value, while for the humidity value, there was an average error value of 24.6-29.4%. The error value is generated from the division between the temperature/humidity difference value from the room thermometer/hygrometer and the temperature/humidity measurement result from the "Shroom Sense" device. The difference in the value of the temperature/humidity measurement results between the thermometer/hygrometer and the "Shroom Sense" device can occur due to the different sensitivity levels of the instrument readings, causing different accuracy levels of temperature/humidity readings.

2. Testing of the Internet of Things (IoT) Based Temperature and Humidity Monitoring System at Mushroom House

The Internet of Things (IoT) based temperature and humidity monitoring system was then tested on actual conditions in the oyster mushroom cultivation barn managed by the Women Farmers Group (KWT) "Sido Makmur" located in Ngaran Hamlet, Gilangharjo Village, Pandak District, Bantul Regency, Special Province of Yogyakarta. The system was tested for 3 days and monitored in real-time and remotely. Detailed test results data can be observed in Table 6 below.

Figure 14. Temperature and Humidity Monitoring Tool at "Sido Makmur" Oyster Mushrooms

Table 6. Test Results

Day/Date	Time	Temperature (∘C)		Humidity (%)	
		SS*	JK*	SS*	JK*
Thursday, September 1, 2022	12.20	29.5	29.5	54	54
	16.00	26.2	26.2	65	65
	19.14	23.5	23.5	67	67
	19.25	23	23	67	67
Friday, September 2, 2022	11.05	24.9	24.9	78	78
Saturday, September 3, 2022	15.32	25.2	25.2	73	73
	15.43	26.3	26.3	69	69

*Description:
SS = "Shroom Sense" Device Measurement Results
JK = Results displayed on the "Jamurku" Application

In the testing and implementation phase of the Internet of Things (IoT)-based temperature and humidity monitoring system, the service team only takes data on the temperature and humidity values of the mushroom displayed on the "Shroom Sense" LCD device and compares them with the temperature and humidity values displayed on the "Jamurku" android smartphone application. Even though there is potential for unstable 2G cellular signal interference at the location of the mushroom shed, which can affect the results of reading the data on the "Jamurku" application, in practice during the test, the results of the temperature and humidity data values are displayed on the LCD of the "Shroom Sense" device, and the results of the temperature and humidity data values displayed on the "Jamurku" application are the same.

In carrying out community service activities planning and implementing appropriate technology in the form of a temperature and humidity monitoring system for oyster mushroom cultivation based on Internet of Things (IoT) technology, the service team faced technical and non-technical obstacles. Technical constraints in community service activities include differences in temperature and humidity measurements between the temperature and humidity sensors used compared to thermometer and hygrometer measuring instruments. Another technical obstacle, users need to pay attention to is if the temperature and humidity monitoring tool cannot transmit sensor data to the Android application on the user's smartphone. It is usually due to the nominal pulse in the SIM card installed on the user's device having run out and needing to be recharged. Meanwhile, non-technical obstacles in community service activities include oyster mushroom farmers as users of temperature and humidity monitoring tools who cannot quickly adapt to the use of electronic devices and smartphone applications used in their mushroom farms because they do not really understand new technology, so they often forget in the operation of the tool. Another non-technical obstacle is the weather factor which greatly influences the optimization of daily yields on oyster mushrooms. Thus, oyster mushroom farmers need to monitor regularly to maintain the environmental conditions of the mushroom house.

Along with the application of appropriate technology in the form of a temperature and humidity monitoring system based on Internet of Things (IoT) technology, the service team has also evaluated the implementation of service to service partners in the form of group discussions (Forum Group Discussion). The FGD was carried out by inviting KWT members "Sido Makmur" to find out to what extent the results of the service can overcome problems and can meet the expectations of service partners. The results of the FGD evaluation concluded that the oyster mushroom farmers who are members of KWT "Sido Makmur" feel enthusiastic and are helped by the technological innovation implemented by the service team, although it takes time and training to be able to operate and get used to using the temperature and humidity monitoring tool. The community service activities that had been carried out by the service team had changed the mindset of oyster mushroom farmers who are used to traditional farming and considered the use of modern electronic devices to be difficult and expensive. With this community service activity, traditional oyster mushroom farmers realize that the use of Internet of Things (IoT)-based technology allows mushroom farmers to monitor remotely so they don't have to make repeated measurements manually in mushroom barns. The application and use of agricultural technology will also encourage optimal productivity and quality of oyster mushroom farming and, in turn, improve the welfare of the oyster mushroom farmers of the service partners.

CONCLUSIONS

The Community Service Program with the Community Partnership Program (PKM) scheme had been implemented by the service team in collaboration with service partners located in Ngaran Hamlet, Gilangharjo Village, Pandak District, Bantul. The Service Partner was the Sido Makmur Women Farmers Group (KWT), whose business sector is oyster mushroom farming. The problem faced by service partners is how to maintain the ideal condition of the mushroom house so that it has constant temperature and humidity so that the mushroom production results are optimal. The ideal temperature for a mushroom house is around 26oC – 29oC, while the ideal humidity for a mushroom house is 70% to 90% RH. To make it easier for partners to overcome these problems, the Service Team has created an Appropriate Technology in the form of a temperature and humidity monitoring system for mushroom houses based on the Internet of Things (IoT), so it is hoped that it will make it easier for mushroom farmers to monitor the conditions of the mushroom cages in real-time and remotely. Based on the results of the implementation, testing and analysis of the temperature and humidity monitoring system in the Internet of Things (IoT) based mushroom house, the system has been able to work properly and optimally in accordance with the system planning expected by the user, both hardware and software. Through this service activity, there is also a change in the mindset of oyster mushroom farmers who were previously accustomed to traditional mushroom farming methods, have realized that the use of Internet of Things (IoT)-based technology allows them to remotely monitor mushroom barns so that manual measurements are no longer necessary. Implementation of this agricultural technology will also encourage increased productivity and quality of oyster mushroom farming products more optimally and ultimately improve the welfare of mushroom farmers. Not only that but with this service activity, it is hoped that more and more residents of Ngaran Hamlet will be interested in pursuing the oyster mushroom farming business and, in the long term, can make Ngaran Hamlet become an independent and prosperous hamlet as a center for oyster mushroom cultivation in Bantul Regency, DIY.

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