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RESEARCH ARTICLE **Open Access**

IoT and Cloud Storage Implementation for Wheat Plant Monitoring at the Tropical Study Center UKSW

Kristian Vieri Marpaung *
Faculty of Information Technology, Universitas Kristen Satya Wacana, Salatiga City, Central Java Province, Indonesia.
Corresponding Email: vierikristian7@gmail.com

Indrastanti R. Widiasari
Faculty of Information Technology, Universitas Kristen Satya Wacana, Salatiga City, Central Java Province, Indonesia.
Email: indrastanti@uksw.edu

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Abstract: Information technology in the agricultural sector has been widely discovered, producing large amounts of agricultural products. This research aims to design and build a tool that implements IoT for monitoring agricultural systems using several sensors, converging data communication simultaneously. The real-time between IoT sensors and databases in Cloud Storage and analyzing the performance of agrarian system monitoring systems by implementing IoT and Cloud Storage in the application link which can be accessed on Android or PC. The test results from this research are the performance of the IoT system, which can be accessed using the application Blynk. This IoT works well. MomentBlynkIoT gives commands to the DHT11 sensor and soil moisture sensor to start reading temperature and humidity and then pass it on to the microcontroller and pass it back; BlynkIoT will provide output to the application display in the form of data resulting from sensor performance.

Keywords: Internet of Things; Cloud Storage; Monitoring Plant Growth; Wheat Plant Growth.

1. Introduction

At the dawn of the 21st century, the rapid proliferation of digitalization marks a pivotal epoch characterized by technological advancement. This transformative era, leveraging technology as its cornerstone for progress, has witnessed unprecedented growth across multifarious domains, facilitating streamlined processes and yielding profoundly positive ramifications [1]. At the vanguard of this digital renaissance lie sensor technology, interconnectivity, and data analytics, coalescing to engender a paradigm shift wherein the integration of these technologies permeates diverse spheres. Among these, the agricultural sector emerges as a salient focal point of development.

The infusion of technology into agriculture epitomizes the application of information and communication technology (ICT) encompassing devices, networks, services, and applications tailored to agriculture [2]. According to reports from MercyCorps and Rabobank, the agrarian landscape in Indonesia is witnessing a surge, with approximately 55 digital technologies finding application within the sector. These technologies predominantly target digital information dissemination, comprising market insights and pricing data, constituting 60% of the digital agricultural initiatives. Concurrently, 40% of endeavours are directed towards enhancing market access, while nearly a third concentrate on fortifying the supply chain and bolstering data management infrastructure. Furthermore, a discernible portion is allocated to augmenting financial services and mechanization within the agricultural domain, notably through adopting Internet of Things (IoT) technology.

IoT, heralded as a cornerstone of technological innovation, epitomizes the interconnectivity of devices facilitating data exchange via internet protocols. This revolutionary technology underpins control, communication, and collaboration among disparate hardware entities, thereby effectuating a seamless integration of data networks. Consequently, IoT serves as a conduit for realizing a connected ecosystem wherein non-human entities interface with the Internet, engendering unprecedented efficiencies and functionalities [3]. Its omnipresence in contemporary society portends a future wherein human-computer interfaces transcend conventional limitations, ushering in an era wherein remote control and management of processes become ubiquitous.

Cloud computing, an indispensable facet of modern IT infrastructure, has garnered widespread adoption within the corporate milieu, particularly among enterprises. However, its potential transcends commercial applications, offering a panacea for the perennial challenge of resource constraints faced by academic institutions, including universities. By harnessing the virtualization of storage, servers, and resources, cloud computing obviates the need for on-premise infrastructure, mitigating data storage, scalability, and bandwidth requisites concerns. In agriculture, where information technology assumes an increasingly pivotal role, cloud computing holds promise as an enabler for the efficient management and storage of agricultural data.

The imperative for Indonesian farmers to embrace technological advancements underscores the exigency of acclimatizing to the evolving landscape of agricultural practices. In a milieu where technology permeates every facet of modern existence, the cultivation of technological literacy among agricultural stakeholders assumes paramount significance. Leveraging advancements in information technology, such as IoT and cloud computing, can empower Indonesian farmers to optimize farming operations, facilitating real-time monitoring and control of environmental parameters critical to crop health and productivity.

Wheat (Triticum aestivum), a staple crop sustaining global food security, epitomizes the quintessential agricultural commodity wherein environmental variables profoundly influence yield and quality. Traditional methodologies for monitoring ecological conditions surrounding wheat cultivation are fraught with limitations, encompassing accuracy, efficiency, and cost-effectiveness issues. The advent of IoT and cloud storage technologies offers a paradigmatic shift, affording researchers and practitioners unprecedented capabilities for real-time monitoring and data storage. Accordingly, the present study delineates the "Implementation of IoT and Cloud Storage Technology for Monitoring Wheat Plant Growth" as a pivotal endeavour to harness technological innovation to optimize agricultural outcomes.

In summary, the inexorable march of digitalization catalyzes a transformative trajectory wherein technology assumes primacy as a catalyst for progress across diverse sectors. The convergence of IoT and cloud computing in the agricultural domain heralds a new dawn characterized by enhanced efficiency, productivity, and sustainability. The seamless integration of these technologies augurs well for the future of agriculture, empowering stakeholders to navigate the complexities of modern agricultural practices with newfound efficacy and resilience.

2. Research Method

A systematic research methodology was adopted to ensure the successful implementation of IoT and Cloud Storage for monitoring wheat plant growth. This section outlines the detailed steps and processes involved in the research. The research methods used can be seen in Figure 1.

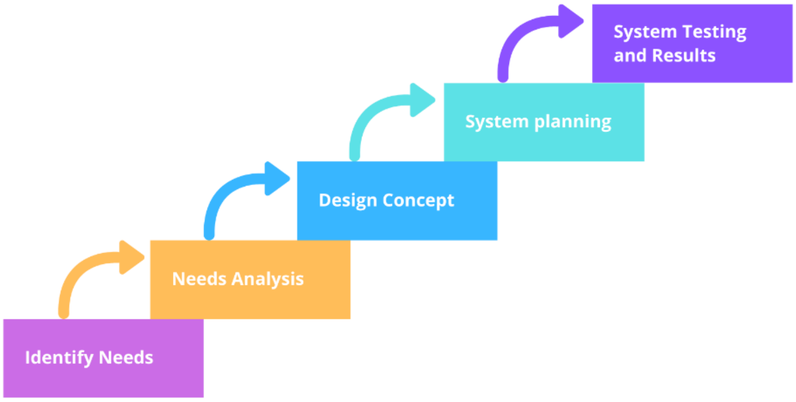

Figure 1. Research Method

Requirements identification is the first step in the development process, which aims to identify the required hardware, software and system requirements. This includes using microcontrollers as tool controllers, sensors as supporting measuring tools, and Blynk applications for cloud storage and remote monitoring. Needs analysis is carried out as a follow-up to needs identification. In collecting data regarding wheat plant growth at the UKSW Tropical Studies Center, the steps taken are as follows; as the main step, NodeMCU V3 is used as a microcontroller to control all tool components. This includes sensor control, sending data to the Blynk application, and displaying sensor data on the I2C LCD screen. The sensors used include the DHT11 sensor to measure air temperature and humidity and the capacitive soil moisture sensor V1.2. These sensors are connected to the NodeMCU V3 ESP8266. The Blynk application is used as a data storage container for each sensor. This application facilitates user wireless access to display the temperature, air humidity and soil moisture data that has been collected. The design of the IoT and Cloud Storage technology system for monitoring wheat plant growth will be carried out to show the system's workflow. The design concept can be seen in Figure 2.

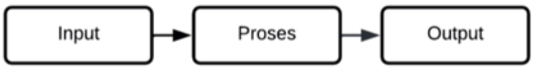

Figure 2. System Block Diagram

The input to the system is the environmental value read by the sensors used. Apart from the sensor reading results, the system also gets input from the Blynk server in the form of set point data sent by the user. With all the input received, the system will carry out processing on the NodeMCU ESP8266 microcontroller controlled by the Internet via WiFi, the ESP8266 chip. In making this tool, an IoT system requires various devices, such as a cloud platform that can be accessed via cellphone to display sensor results or remote control. The Cloud Platform functions as a data container. The IoT cloud platform has provided a cloud for data storage. Both methods tend to be the same: sending data to the cloud and accessing data in the cloud. The cloud is like a space to put things. So this item can be placed in that space, then if we need it, we need to enter that space to access it, for example, using a cell phone. This section explains component design, system block diagrams, design, and tool circuit schematics. In making this tool, the NodeMCU ESP8266 module was used as the microcontroller or main system to control several other components. From the microcontroller, all processes can be carried out, starting from reading commands, executing commands and sending back the results of commands that have been processed. Some of the components include a DHT11 sensor for measuring air temperature and humidity, a soil moisture sensor and an I2C LCD.

Table 1. ESP8266 NodeMCU Port – Sensor – LCD I2C

NodeMCU	LCD I2C	DHT11	Soil Moisture Sensor
GND	GND	GND	GND
VU	VCC		
A0			AOUT
3V		VCC	VCC
D1	SCL		
D2	SDA		
D3		OUT	
D4			

In designing this media, software is needed to run each component according to instructions. In this research the author used C programming language to program a microcontroller compiled by the Arduino IDE. Before continuing to write the program, first create the algorithm that will be used so that it runs well according to the design of the system, then the algorithm that has been written in the program will be converted into a flowchart after which the program is created in C language. The Pseudocode for IoT Technology Systems and Cloud Storage is below:

```
KONSTAN BLYNK_TEMPLATE_ID <- "TMPL6-UzhR2cE"
KONSTAN BLYNK_TEMPLATE_NAME <- "Sensor Kelembaban Tanah dan Suhu"
KONSTAN BLYNK_AUTH_TOKEN <- "lnwdN77kdwyPACsqRpmRyt7KL8wdcKnw"
KONSTAN BLYNK_PRINT <- Serial

SERTAKAN <ESP8266WiFi.h>
SERTAKAN <BlynkSimpleEsp8266.h>
SERTAKAN <Wire.h>
SERTAKAN <LiquidCrystal_I2C.h>
SERTAKAN <DHT.h>

INISIALISASI lcd SEBAGAI LiquidCrystal_I2C(0x27, 16, 2)
INISIALISASI dht SEBAGAI DHT(D3, DHT11)

VARIABEL auth <- BLYNK_AUTH_TOKEN
VARIABEL ssid <- "SSID"
VARIABEL pass <- "PASSWORD"
INISIALISASI timer SEBAGAI BlynkTimer
KONSTAN AirValue <- 633
KONSTAN WaterValue <- 292
VARIABEL soilMoistureValue <- 0
VARIABEL soilmoist <- 0
VARIABEL mode <- 0
FUNGSI baca_Sensor():
    soilMoistureValue <- bacaAnalog(A0)
    soilmoist <- map(soilMoistureValue, AirValue, WaterValue, 0, 100)
    JIKA soilmoist >= 100 MAKA
        soilmoist <- 100
    ELSE JIKA soilmoist <= 0 MAKA
        soilmoist <- 0
    VARIABEL humidity <- dht.bacaKelembaban()
    VARIABEL temperature <- dht.bacaSuhu()
    lcd.init()
    lcd.backlight()
    KASUS mode:
        KASUS 0:
            lcd.setKursor(0, 0)
            lcd.tulis("Tanah = ")
            lcd.tulis(soilmoist)
            lcd.tulis("%")
            Blynk.tulisVirtual(V0, soilmoist)
        KASUS 1:
            lcd.setKursor(0, 0)
            lcd.tulis("Suhu = ")
            lcd.tulis(temperature + 2)
            lcd.tulis("C")
            Blynk.tulisVirtual(V1, temperature + 2)
        KASUS 2:
            lcd.setKursor(0, 0)
            lcd.tulis("Kelembaban = ")
            lcd.tulis(humidity)
            lcd.tulis("%")
```

```
            Blynk.tulisVirtual(V2, humidity)
    mode++
    JIKA mode > 2 MAKA
        mode <- 0
DEFINISI setup():
    Serial.begin(9600)
    Blynk.begin(auth, ssid, pass)
    lcd.begin(16, 2)
    lcd.backlight()
    dht.begin()
    timer.setInterval(5000L, baca_Sensor)
DEFINISI loop():
    Blynk.jalankan()
  timer.jalankan().
```

3. Result and Discussion

3.1 Result

3.1.1 System Architecture Design

In designing the system architecture, this is done by studying existing research. The background of this research is that they both use the DHT11 sensor to determine air temperature and humidity and the soil moisture sensor to determine the water content in the soil. The research that the author conducted used a system consisting of an ESP8266 as the main controller that reads sensor data. Data will be displayed on an LCD and sent wirelessly via Wi-Fi to the Blynk platform. From there, users can carry out real-time environmental monitoring via an application on a mobile device. The working principle of the IoT and Cloud Storage technology systems can be seen in Figure 3. The relationship between connected components and the occurrence of input to certain elements can be explained to produce an output. As a microcontroller, the 12C LCD and ESP8266 module are the main components that regulate the entire input and output work process. Using the DHT11 sensor and soil moisture sensor, the monitoring system will read changes in temperature, soil humidity, and air humidity, and the data will then be sent to the NodeMCU ESP8266. Data from each sensor is sent to Blynk IoT.

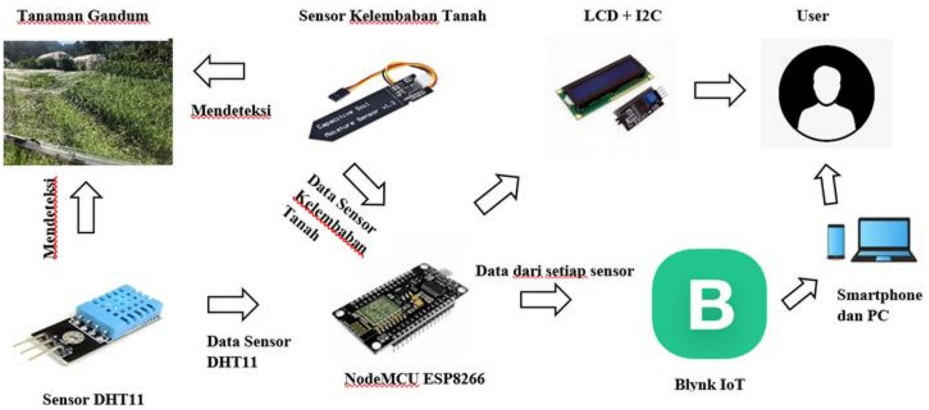

Figure 3. IoT Technology and Cloud Storage System Architecture for Monitoring Wheat Plant Growth

The monitoring system flowchart can be seen in Figure 4. The flowchart explains that when it is first turned on, the tool will initialize the device and connect to Wi-Fi; when it is connected to Wi-Fi, this is followed by Blynk initialization and a timer to read the sensor. Then, the program will enter a main loop where it continuously calls the functions of blynk. Run () and time. Run () and regularly contact the sensor reading function to read the sensor, update the LCD and send data to the Blynk application. Once all steps have been executed properly, the step will be completed, and the program will end.

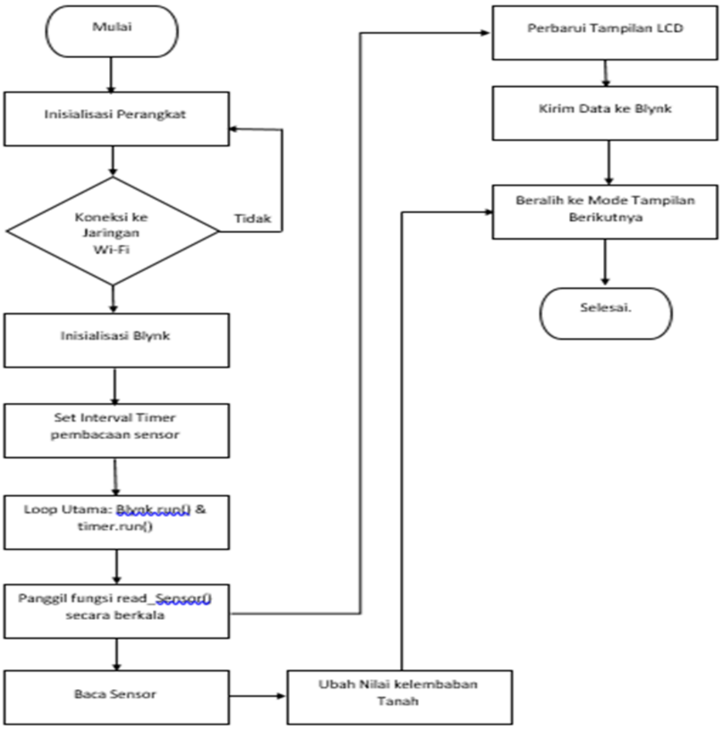

Figure 4. Flowchart of IoT and Cloud Storage Technology Systems for Monitoring Wheat Plant Growth

The mechanism of how the IoT and Cloud Storage technology system works for monitoring wheat plant growth is that the DHT11 sensor and soil moisture sensor are installed on the NodeMCU ESP8266 which is placed in the wheat plantation area at the UKSW Tropical Study Center. When using this system, if the user activates the device and the connection to WiFi is successful, the system will give commands via the microcontroller to retrieve data via sensors and send the data to Blynk IoT which can be seen by the user from the device and laptop when accessing the application. When the process is complete, the user will easily access temperature and humidity data in the Blynk IoT application using the Gauge element to display temperature and humidity.

3.1.2 IoT and Cloud Storage Technology System Testing

The system testing was carried out by connecting the microcontroller to the adapter. The user will plug in the soil moisture sensor first and let the microcontroller carry out the commands that have been made. The tool will send and display existing data into the Blynk IoT application and I2C LCD if connected to the internet network. If so, the data sent by the sensor via the microcontroller can be downloaded and further analyzed by the user. The results of the test can be seen in Figures 5 and 6.

Figure 5. Sensor data displayed on the I2C LCD

Figure 6. Data displayed in the Blynk Mobile application

3.1.3 DHT11 Sensor Testing

Testing of the DHT11 sensor was carried out by comparing the temperature and humidity value readings from the DHT11 with the temperature and humidity value readings using a room thermometer hygrometer.

Table 2. Test Results of the DHT11 Sensor with a Room Hygrometer Thermometer

No.	Time	Humidity (DHT11)	Humidity (Thermometer Hygrometer)	Air Temperature (DHT11)	Air Temperature (Thermometer Hygrometer)
1	02/12/2024 08:15	28	85	27	85
2	02/12/2024 08:14	28	85	28	85
3	02/12/2024 08:13	28	85	28	85
4	02/12/2024 08:12	28	85	28	85
5	02/12/2024 08:11	28	28	28	28
6	02/12/2024 08:10	27	87	27	87
7	02/12/2024 08:09	27	82	26	82
8	02/12/2024 08:08	26	82	26	82
9	02/12/2024 08:07	26	81	26	81
10	02/12/2024 08:06	27	79	27	79
11	02/12/2024 08:05	28	80	28	80
12	02/12/2024 08:04	28	78	28	78
13	02/12/2024 08:03	29	77	29	77
14	02/12/2024 08:02	29	77	29	77
15	02/12/2024 08:01	30	78	30	78
16	02/12/2024 08:00	29	77	29	77
17	02/12/2024 07:59	28	79	28	79
18	02/12/2024 07:58	27	83	27	83
19	02/12/2024 07:57	27	82	27	82
20	02/12/2024 07:56	28	82	28	82
21	02/12/2024 07:55	28	82	28	82
22	02/12/2024 07:54	27	81	27	81
23	02/12/2024 07:53	28	79	27	80
24	02/12/2024 07:52	27	79	27	79
25	02/12/2024 07:51	26	80	27	79
26	02/12/2024 07:50	27	79	27	79
27	02/12/2024 07:49	27	79	27	79
28	02/12/2024 07:48	27	79	27	79
29	02/12/2024 07:47	27	79	27	79
30	02/12/2024 07:46	27	79	27	79
31	02/12/2024 07:45	26	81	27	80
32	02/12/2024 07:44	26	82	26	81
Amount		822	2212	821	2210
Average		27.46	79.09	27.43	79.03

Right To determine the comparison between the results of the system and the Thermometer Hygrometer tool, the following formula is used:

$$\left(\frac{New\ Value - Old\ Value}{Old\ Value}\right) x\ 100\ \%$$

So you get the results of the comparison of air temperature and humidity as follows:

$$\frac{27,46 - 27,43}{27,43}\ x\ 100\% =\ 0,1092\%$$
$$\frac{79,09 - 79,03}{79,03}\ x\ 100\% =\ 0,075\%$$

The test results show that the comparison is very small, with only 0.1092% between the temperature reading of the DHT11 sensor and the temperature reading by the thermometer. Meanwhile, the accuracy of measuring air humidity with the DHT11 compared to measuring air humidity with a hygrometer thermometer is not very significant, with a ratio of 0.075%. 4.5.2 Soil Moisture Sensor Testing. Testing of the soil moisture sensor was carried out by comparing the soil moisture value readings from the soil moisture sensor with the humidity value readings using the MC-7828SOIL.

Table 3. Soil Moisture Sensor Testing Results with MC-7828SOIL

No.	Time	Humidity Sensor	MC-7828SOIL Soil
1	02/12/2024 08:15	42	43
2	02/12/2024 08:14	43	43
3	02/12/2024 08:13	43	43
4	02/12/2024 08:12	43	43
5	02/12/2024 08:11	43	
6	02/12/2024 08:10	44	43
7	02/12/2024 08:09	44	44
8	02/12/2024 08:08	44	44
9	02/12/2024 08:07	44	44
10	02/12/2024 08:06	44	44
11	02/12/2024 08:05	44	44
12	02/12/2024 08:04	44	44
13	02/12/2024 08:03	44	44
14	02/12/2024 08:02	44	44
15	02/12/2024 08:01	44	44
16	02/12/2024 08:00	44	44
17	02/12/2024 07:59	44	44
18	02/12/2024 07:58	44	44
19	02/12/2024 07:57	44	44
20	02/12/2024 07:56	44	44
21	02/12/2024 07:55	44	44
22	02/12/2024 07:54	44	44
23	02/12/2024 07:53	44	45
24	02/12/2024 07:52	44	45
25	02/12/2024 07:51	44	45
26	02/12/2024 07:50	44	45
27	02/12/2024 07:49	44	45
28	02/12/2024 07:48	44	44
29	02/12/2024 07:47	44	44
30	02/12/2024 07:46	43	43
31	02/12/2024 07:45	43	43
32	02/12/2024 07:44	42	43
Amount		1398	1405
Average		43.68	43.90

To determine the comparison of the results of the soil moisture sensor and the MC-7828SOIL tool, the following formula is used:

$$\left(\frac{New\ Values - Old\ Values}{Old\ Value}\right) x\ 100\ \%$$

$$\frac{43{,}68 - 43{,}90}{43{,}90}\ x\ 100\% = \ 0{,}5038\%$$

The test results show a very small difference with an error of only 0.5038% between the soil moisture sensor temperature reading and the temperature reading by the MC-7828SOIL. Based on the results of testing the tool and integrating sensor work into the program as well as testing the monitoring and control functions, the successful work of the tool and system can be described as follows:

Table 4. Table of Testing the Work Success of Tools and Systems

No.	Test Parameters	Succeed	Not Successful
1	Upload Program to Microcontroller	✓	
2	The DHT sensor is able to read the temperature and humidity of wheat plants	✓	
3	The Soil Moisture Sensor is able to read the soil moisture of wheat plants	✓	
4	Network connection system between Blynk and microcontroller	✓	
5	Testing of temperature and humidity monitoring systems	✓	
6	Soil moisture monitoring system testing	✓	
7	Network connection system between Blynk and microcontroller	✓	

The overall testing of tools and systems worked well by producing successful scores in all tests. The error produced by each sensor is also very small, making the monitoring function relatively good and accurate.

4. Related Work

Research conducted by Wijaya and Wellem (2022) entitled Design and Implementation of an IoT-based Temperature and Water Level Monitoring System in an Ornamental Fish Aquarium this research aims to design and implement a temperature and water level monitoring system in an IoT-based aquarium [4]. The hardware in this system is implemented using a NodeMCU ESP8266 as the main controller and a WiFi module that connects the system to the Internet, a DS18B20 temperature sensor, an HCSR04 ultrasonic sensor, and relays to turn on and turn off equipment controlled by the system. In addition, Telegram bots are used to provide commands to maintain equipment and receive notifications from the system. Research conducted by Prakoso (2022) entitled Design and Implementation of an IoT-based Air Quality Monitoring System using Wemos D1 Mini and Android aims to design and implement an IoT-based air quality monitoring system [5]. The hardware in this system uses a Wemos D1 Mini board, an MQ-9 gas sensor to measure CO gas levels and an MQ135 gas sensor to measure CO2 gas levels. An Android-based application is also implemented to access and display the results of air quality measurements by the system, which are stored in a cloud database (Firebase). System testing used smoke originating from burning paper at varying distances from the sensor. Research conducted by Akbar (2020) entitled Implementation of IoT Technology and Cloud Storage for Monitoring and Controlling Web-Based Laying Chicken Cages this research aims to Design and build an IoT device for laying hen cages using several IoT sensors used in monitoring and controlling IoT devices on Smart chicken coop [1]. Research conducted by Sutanto, Ningsih and Arianto (2020) entitled Monitoring the Quality and Volume of Fresh Milk in IoT-based Cold Storage this research aims to design IoT Master and Agent devices that can be used to solve the problems of storing, monitoring and controlling fresh milk supplies [6]. The IoT Node consists of room temperature, milk temperature, Ph meter and ultrasonic sensors. The IoTNode will process data from the sensors and then sent to the IoT Master Controller. The IoT Master Controller will send data to the cloud server. Research conducted by Suherman and Suteja (2020) entitled Implementation of Internet of Things Technology for Monitoring Air Temperature, Air Humidity, Discharge and Water PH in Hydroponic Planting Media, this research aims to be able to design a parameter data collection system for hydroponic garden media, and this data can be saved and displayed in the form of graphic visualization of the results of data recording that has been carried out [7]. The entire system will use Internet of Things, Internet technology using Arduino Uno as a computer toto run the system. The system will use three types of sensors with different functions, which will be used to record the data required according to the system implementation objectives. Apart from collecting data, the system will also upload data to Thingspeak, which will be used to visualize the results of the data recording that has been carried out. That way, the results of data recording can be monitored remotely without having to be directly monitored manually. An IoT and Cloud Storage technology system for tracking the growth of wheat plants based on a microcontroller was created using the design method. In order the method used is an analysis of the required requirements. The needs are then identified to obtain specific components, and then hardware and software design is carried out, followed by manufacturing and testing of tools. Research conducted by Arifin (2021) entitled Implementation of Internet of Things in the Prototype of a Cloud Storage and Android-Based Security System for Swiftlet House aims to implement IoT in designing a security system prototype for a Swiftlet house, utilizing cloud storage and Android for data storage and remote monitoring [8].

Research conducted by Dwipayana, Sukarsa, *et al.* (2022) entitled Utilization of Dropbox Cloud Storage and Dropbox API as Media for Data Storage and Exchange in Web-Based Information Systems explores the application of Dropbox Cloud Storage and Dropbox API for efficient data storage and exchange in web-based information systems [9]. Li, Ota, and Dong (2018) research entitled Learning IoT in Edge: Deep Learning for the Internet of Things with Edge Computing investigates the use of deep learning in edge computing to enhance IoT systems [10]. Research conducted by Murray (2018) entitled Cloud Storage Encryption and by Vasudevan (2020) entitled Cloud Storage System both examine various techniques and systems for securing data in cloud storage environments, emphasizing the importance of data security and encryption in IoT applications [10][13]. Research conducted by Sanjaya, Pranoto, and Wahyuni (2021) entitled Application of IoT (Internet of Things) for Monitoring Mosque Congregations by COVID-19 Health Protocols Using Arduino focuses on the use of IoT for monitoring mosque congregations to ensure adherence to COVID-19 health protocols [12]. In developing an IoT and Cloud Storage technology system for tracking the growth of wheat plants based on a microcontroller, the method used includes analysis of the required requirements. The needs are identified to obtain specific components, followed by hardware and software design, and then the manufacturing and testing of tools. Based on this research, the DHT11 sensor demonstrated a temperature reading accuracy with a margin of error of 0.1092% and an air humidity reading accuracy with a margin of error of 0.075%. The soil moisture sensor also showed a margin of error of 0.5038%. Overall, the tool and system performed successfully during testing, providing good and reliable performance for monitoring the environment around wheat plants.

5. Conclusion

Based on the findings of this research, the IoT and Cloud Storage technology system designed for monitoring the growth of wheat plants demonstrated notable accuracy and reliability. The DHT11 sensor, employed for measuring temperature and air humidity, exhibited a very low margin of error, with a temperature reading accuracy deviation of just 0.1092% and an air humidity reading deviation of 0.075%. These results highlight the sensor's precision and suitability for environmental monitoring applications. Similarly, the soil moisture sensor showed a deviation of 0.5038%, indicating its effectiveness in accurately measuring soil moisture levels, which is crucial for optimal plant growth and health. This level of accuracy ensures that the sensor can reliably inform users about the moisture content of the soil, aiding in effective irrigation management. Throughout the testing phase, the entire system functioned seamlessly, comprising the NodeMCU ESP8266 microcontroller, sensors, and the Blynk application for data storage and remote monitoring. The integration of these components facilitated real-time data collection and visualization, enabling users to monitor environmental conditions remotely. This capability is particularly advantageous for agricultural applications, where timely and precise data can significantly impact crop management and yield. This system's successful implementation and performance underscore its potential for broader applications in agriculture and other fields requiring environmental monitoring. By leveraging IoT technology and cloud storage, this system provides a scalable and efficient solution for continuous monitoring and data analysis. The research validates the effectiveness of the proposed system in delivering accurate and reliable environmental data. The low margins of error in sensor readings affirm the system's capability to effectively monitor wheat plant growth conditions. This research contributes to the growing body of knowledge in IoT-based agricultural solutions and paves the way for future innovations to enhance crop management and productivity through advanced monitoring technologies.

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