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# IOT SENSOR TECHNOLOGY AND CLOUD APPLICATION ON FARMING PRACTICE: PLANT LIVE DATA MONITOR IN AGRICULTURE

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ABSTRACT

*Modern farming practices emphasize cutting-edge technology for plant data monitoring since data monitoring enables farmers to promote sustainable farming practices in fieldwork. World agriculture is looking at sustainable management practices on agricultural farms. Real-time plant data monitoring gets priority in precision farming, making farmers informed plant decisions. The study aims to design a sensor and cloud application for farmers' plants' live data monitor that provides an opportunity for earlier disease and pest detection to control long-term and effective agricultural development and provides sensor wireless network support to track plants' natural characteristics and anomalies detection. This research investigates sensor applications in farming practices to collect plant live data to produce information before making decisions about plants by farmers. The application applied the MySQL cloud database to store plants' analogue data; smart devices connect farmers to the plant field virtually. The article experiment reveals that remote farmers can direct plants' current condition to the environment. Farmers get support to take immediate actions based on live data behaviour in an innovative way; thus, fast response for plants improves production quality and optimizes resource use. The study found that live data monitoring with a sensor network and cloud server application provides a technology-driven data collection model that efficiently analyzes data interpretation for farming practices.*



## INTRODUCTION

Innovative technology has changed conventional farming output into the modern farming industry. Global agriculture has experienced farming challenges through traditional agriculture criteria without using advanced smart farming policies. Modern farming is being followed by world agriculturists/farmers; therefore, adopting smart farming practices is needed to meet the growth demand for agricultural products. Natural ecosystems with environmental disaster threats and crop field agriculture are likely to shift towards sustainable agriculture quickly. Industrial revolution technology shows directly an agricultural revolution from traditional to smart agriculture with emerging sensor technology used in farming to make it sustainable.

Food production, supply in the market, user demand, the price set in the market, and service for farmers and end users are highly related to agriculture and business, i.e., agribusiness. Its branch significantly employs farming and agricultural practices. While agriculture deals with the development of crops, soil, and food production, other cases keep agriculture under commercialization, causing no agricultural production value in the supply chain. The food market demands to feed seventy per cent of the population by 2050 and needs more consumption demand for increased consumption in the future world, according to Ravi and Gopal (2017). Therefore, food demand will surge demanding in future farming emphasizing IoT (Internet of things) and IofT (Internet of farm things) that could assist in food production. Internet of Farm

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Things (IofT) smart devices are used to monitor field analogue data and data from crop growth zoon. IofT devices are technologically used in innovative agricultural farming practices.

Besides, the article (Quddus & Kropp, 2020) investigated agricultural farmers living with challenges, especially in the lagging regions of Bangladesh, and their farm income, agricultural practice, input patterns, and farmers' technical support survey most people here earn from agricultural production like others country community hence technology priority should be given into agricultural practice for lagging regions farmers. Another article (Farooq et al., 2020) surveyed IoT technology and technology solutions to meet context quality and quality production demand for agriculture industrialization. Sensor wireless networks help farmers collect crop information, and cloud services allow farmers to access field data remotely to make crop decisions. Crop production-related climate change and soil moisture issues are addressed (Dhanaraju et al., 2022). To improve crop production and reduce the use of fertilizers and pesticides, consider the advancement of IoT technology in automatic agricultural operations, such as utilizing communication infrastructure, acquiring data, intelligent information systems, decision-making, etc. Jurišić et al. (2021) encompassed frequently used sensors in agriculture applications and depicted sensor types according to detection, recording, measuring, and data representation. The application of various sensors records the real-time in farm production processes. Sensor technology is operationally efficient, and it can accurately detect data factors. Authors claimed that sensor technology made precision agriculture development.

Furthermore, Nakhon et al. (2017) examined how technology can solve many traditional farming issues, such as manual labour price, improper water management, and environmental change conditions. Proposed smart farming techniques using sensor devices can accurately detect humidity, temperature, and water levels in the soil, and explained three key components to implement the smart farming model sensor device, gateway, and cloud service. Industrial technologies used in agricultural experiment fields are likely to grow merely high-quality production and quantity and decrease farm manual labour, i.e., using smart devices like smartphones, sensors, robotic applications, smart irrigation, field root data analysis, etc.

Technology applications have a significant impact on agricultural production systems. Sensor technology is a potential key driver to transform agriculture to digitalization. Sensor application helps farmers prevent crop diseases, assess plants' health, and improve data and information analysis to produce yields. The sensor revolution in technology significantly impacts all farming practices and management systems. Sensor technology can assist in environment, soil, and plant growing conditions, monitoring trees' health factors, mapping their biological viability, detecting growing risks, and so on (Kayad et al., 2020) discussed sensors application.

The above studies examined different technologies and found IoT sensor applications, cloud services, smartphones, and robotics transforming agriculture to industrialization. Hence, IoT-based smart devices provide more agricultural benefits in farming practices than traditional agricultural production processes for industry. The smart production strategy helps farmers make knowledge-based decisions in farming practices. Farmers can be alert about crop insect attacks and natural calamities by using devices through notifications. Farmers are becoming smarter in agricultural work. The article (Rubio & Más, 2020) says modern farming can manage agricultural goals with objective information emerging from data-driven solutions in farming.

Also, Klerkxa et al. (2019) picked digital agriculture's social and economic conditions. Agriculture 4.0. It employs precision farming and digital agriculture, linking modern digital agricultural practices with farm diversity and transparent production in the supply value chain. Big data, the Internet of Things, robotics, sensors, drones, 3D printing, and artificial intelligence are many forms of digitalization applied in modern digital agriculture. Kilpatrick and Johns (2003) studied how farmers learn farming and business management to follow strategic and tactical changes. Farmers learning change farm management successfully, marketing practice makes capability to make them outward looking and focused on people connecting extensive networking.

Internet technology and communication are applied to farm management in agriculture and modern gardening. The U.K. farm business adopts Internet technology for agricultural business. Farmers apply e-commerce technology to launch small to medium-sized enterprises (Warren, 2004). In contrast, farmers use internet technology for agricultural microbusiness, resulting in agricultural development and human capital-related commercial business. Another study examined that agriculturists are highly influenced to apply I.C.T. and IoT technology in farming practices. The modern gardening system follows I.C.T. technology to handle information management system (Wang et al., 2010) and hold essential guidelines for garden marketing such as planting, seeding, caring, harvesting, maintenance, spraying, and monitoring are tracked down using technology. Another article (Tiwari et al., 2016) wrote on CAD (computer-aided designing) developed for landscape gardening that creates 2D and 3D gardening models using computer application software. Agricultural IoT development for garden planning and flower design management, smart gardening proposed (Jia, 2021). IoT technology developed machine-based irrigation systems that assist farmers in getting more relevant information for better decisions (Ragab et al., 2022) to make agriculture more sustainable. Robotics knowledge is applied to operate complex tasks for a human expert. Smartphones with digital features and more powerful computing devices are added to farming practices (Pongnumkul et al., 2015). Now, producers can work and run farm businesses using a smartphone. IoT and cloud service applications based on cloud technology are powerful and demandable online applications for farming to fix traditional agricultural challenges (Awan et al., 2021). IoT services in agriculture require low power, maintenance, and installation costs to operate and also provide more robust network connectivity among farming agents, ensuring agricultural and industrial zones with large-scale production parameters (Basnet & Bang, 2018). According to Obaideen et al. (2022) designed a sensory smart irrigation system, highlighting precision farming with low-cost IoT technology. The technique developed a network of wireless sensor nodes used by irrigation systems to sense, compute, and transmit information on different essential parameters to control the growth of plants. The authors considered two types of irrigation systems, i.e., suspended cycle irrigation systems based on traditional timer controllers and water-on-demand irrigation that sets the threshold to meet soil-required moisture. Therefore, the authors explored survey articles related to modern agricultural technology that result in IoT sensors and cloud applications that have brought modern farming practices, and embracing these technologies illuminates the challenges of increasing production demands.

The paper is organized into several sections, including an introduction explaining sensor technology development in agriculture, application process, and controlling farm management using modern technology. The section on materials and methods describes the model flowchart, sensor application and configuration for plant data collection, and farmers' mobile app configuration. The result and discussion section presents output in the serial monitor of sensor data values, cloud-designed live database, and farmers' mobile notifications. Lastly, the conclusion section shows agricultural field research findings, limitations, and future research applications.

## MATERIALS AND METHODS

The proposed article application flowchart is presented in figure1. I defined all IoT sensor devices as configured to retrieve data from plant areas. The collected data is in analogue format; hence, information must be processed from analogue data. IoT microcontrollers can read analogue data and convert it into readable format. Then, plant data and information are easily accessible by field designers. The IoT sensor technology circuit is designed to connect plant field data directly to the computing chips of the microcontroller. Retrieve sensor data needs to be sent to the cloud database for storage, so the cloud database (MySQL) query is open-source and is preferred to be implemented for our research experiment. The database is initially empty because manual data are not kept in the dataset. Only plant live data are stored here.

Dataset designed for plants' live data type. If the data type does not fit, a false value will be generated as identification in the decision-making stage, i.e., 'Is cloud storage connected or not?'. Microcontroller and cloud storage connection established include php script coding. Retrieved plants' analogue data cannot be performed before any logical processing; hence, serial plotters and monitors capture real-time live plant data to check the data connection channel from the IoT sensor to the microcontroller.

Online database storage plants live data, so we designed a cloud server database. Cloud technology database load in the online version can hold dynamic data changes in a real-time environment. All data are stored as a sensor data type with a mention of time and date. In other cases, data connection failures like internet interruptions or troubleshooting problems with missing data can be figured out quickly. Hence, time stamp data needs to be designed on a cloud database. The primary key is defined as unique data indexing; therefore, no mismatching data are found on the online cloud database, or if data redundancy occurs, it's quickly possible to remove it from the database.

An internet connection, i.e., wifi or mobile data, establishes a communication channel between plants' live data and plant designers so that smart mobile applications monitor plants' live data as long as the database demands. Smartphones have the advantage of using Bluetooth systems and pairing capabilities with other devices. Allowing pairing Bluetooth devices, plant designers get current mobile notifications in their hands. Live data connected to sensor devices and analogue data from plants to receivers is updated until applications automatically stop. Once data retrieval starts, it automatically sends data to the server without human interruption until it stops programming code.

Then, microcontroller commands upload and verify post data, whereas analogue data begins to be retrieved from the field, and stored data is automatically visible on the cloud database. Cloud online servers store live plant data and make it presentable to plant designers/farmers in the mobile application, which is compatible with pairing. In the disconnection of the database or sensor device, power immediately informs the plant designer there is a connection error or missing information for Live data retrieval of plants.

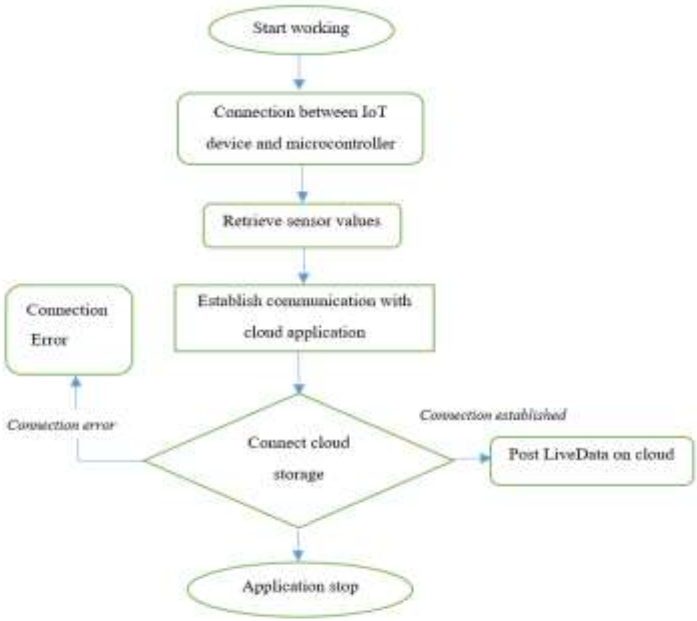



Figure 1. Data collection and cloud storage workflow

## RESULTS

### Experiment Configuration and Result Design

IoT sensor technology has many types; three types of sensors are applied to field data collection for experiment purposes. Soil moisture, temperature, and humidity sensor technology are applied to plant field data and designed on the circuit board for data retrieval.

Arduino microcontroller receives data from sensor devices, and Arduino software writes programming code to implement sensor data. Arduino uploads the code, and the serial monitor screen makes data visible in readable data format. The agricultural plant data research model requires Arduino software, application library files with IoT sensors, and a microcontroller—circuit designed on a Breadboard plate. The microcontroller connects breadboard positive (+) and negative (-) connection pins using a few jumper wires. The Arduino board model U.N.O. R3 was designed for experimentation.

Analogue plant live data is directly recorded from the plant root environment using sensor technology, i.e., soil moisture, temperature, and humidity sensors. The moisture sensor needs a VCC pin connected to an Arduino 5V pin, a GND pin to an Arduino GND pin, and then an analogue output (A.O.) pin to an Arduino analogue port A2 pin. Temperature and humidity sensor values are retrieved using a DHT11 sensor with three pins. The data pin of the sensor is connected to board digital port 2—the other two pins, including ground and power, are connected to Arduino pins, respectively. The ESP32 chip microcontroller supports wifi and Bluetooth connection to the internet and smart mobile phones. Arduino Bluetooth Module HC-05 is part of the circuit design to get notifications on mobile phones via Bluetooth.

Model design local server using xampp, including two modules, Apache and MySQL. Before the application triggers, it must install devices—a cloud technology online cloud server designed to store real data from plants. Live data are stored on the localhost/phymyadmin cloud server. Data change automatically reflects on cloud storage. The experiment model created a database with five variables, i.e., plant's id: primary id, that each plant data has a unique number identification. Moisture_data: Retrieve live plant data from the field using a moisture sensor device. Temperature_data: holds weather temperature using the dht11 sensor, and humidity_data collects humidity data using the dht11 sensor. The Data_record_time variable shows the data collection time and date. For every sample data collection, five variable values are inserted into the cloud database from the plant's root zone. Plant I.D. is an auto-generated number, so data redundancy can be traced. Sensor values in the database are stored only integer (INT) numbers. Figure 2 shows the experiment configuration step by step. Arduino IDE software designed Arduino 2.2.1 version. Library files are required to be installed for sensor data reading. D.H.T. sensor library 1.3.7 and <Wire.h>, <WiFi.h>,<HTTPClient.h>,<DHT.h> library files are attached with program software. Arduino board port COM3 is selected to upload code, and the result is displayed on the serial plotter and monitor.

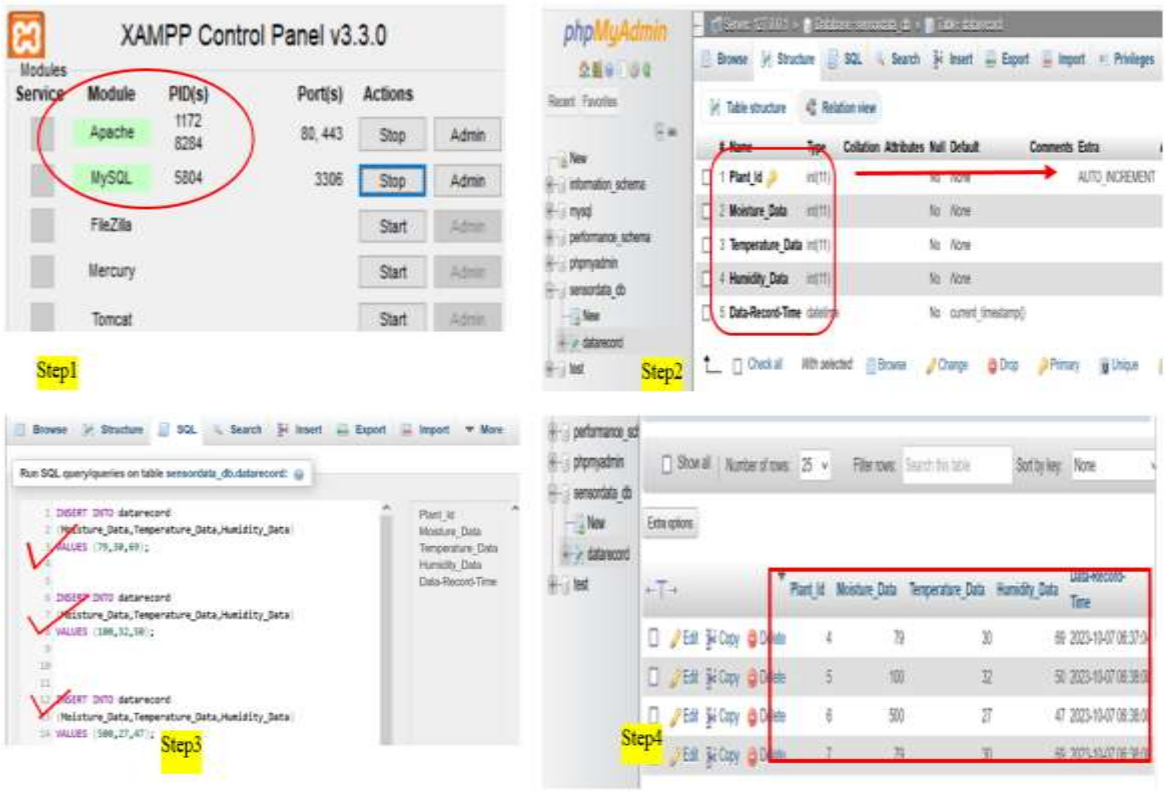



Figure 2. Experiment with configuration and set database design

Coding implementation to collect live data from plants is shown in Figure 3. Variables to collect sensor values temporarily are initialized as zero values. Three values are declared according to a cloud server's phpmyadm in database design. URL holds the Xampp file location with the local computer's IP address. Figure 4 presents how the ESP32 board with Arduino IDE uses the post method to send data from Arduino IDE to the cloud site.

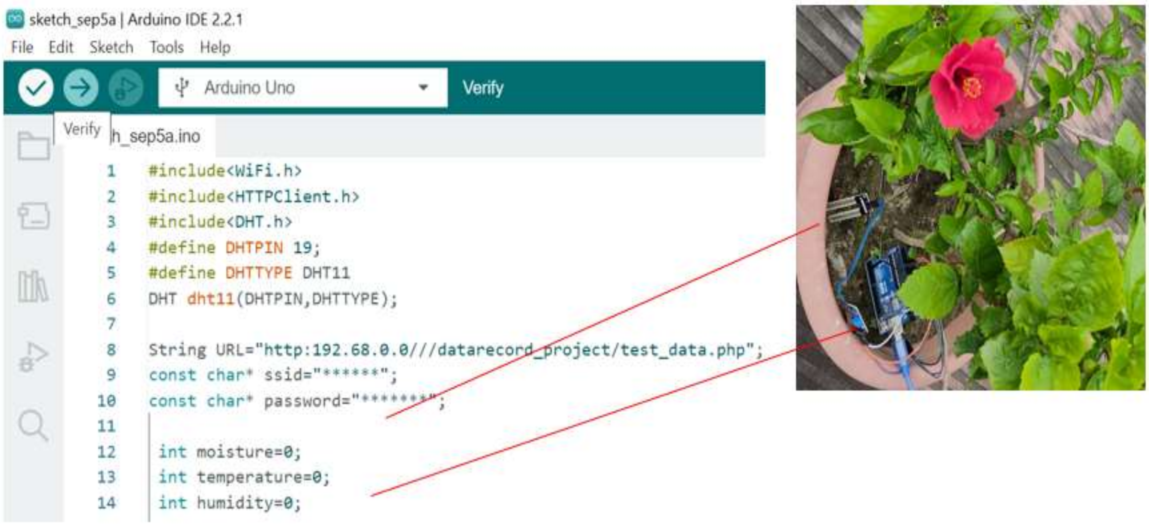



Figure 3. Plants' Live data retrieval process through the sensor


Figure 4. ESP32 connected and retrieved plants' live data

Figure 5 depicts the ways of PHP scripting code for SQL queries in cloud databases to store live data entry. The isset() function checks whether three data variables are retrieved from the plant. The function returns an actual value if the variables are filled and are not NULL. Otherwise, the function returns a false value. Coding SQL variable holds insertion query into the database while query successfully done results echo (print) denotes record completed. Plant designers have the mobile Bluetooth app ‘Arduino Bluetooth Receiver’ to open ArduTooth to pair the H.C. 05 module with a smartphone to get plant sensor values as notifications.


Figure 5. Mysql database, Arduino Bluetooth Receiver, and H.C. 05 module plant data presentation

## DISCUSSIONS

The experiment output is shown in Figure 6 to upload the Arduino IDE code. The serial monitor in Arduino software displays the output result. Three sensor values are retrieved from plant accurate data—live data value changes with time milliseconds, accounting for two to five milliseconds in programming code. Sensor A.D.C. value is calculated in output monitor by soil moisture sensor that detects plants value min 302 and max 341. Moisture A.D.C.'s high value defines soil as not moisture, and A.D.C.'s low value defines the soil as moist as the recorded amount. At the same time, temperature sensors sense weather temperatures nearly 30 $^{o}$c. The cloud server database is designed to store only integer temperature data values in phpmyadmin, stores 30 $^{o}$c and the humidity sensor retrieves 83 per cent values in a particular time.

Moisture sensor data          Temperature sensor data          Humidity sensor data

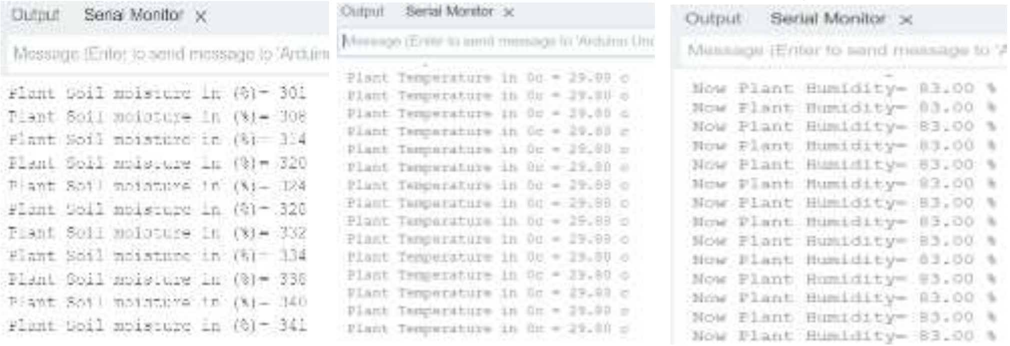
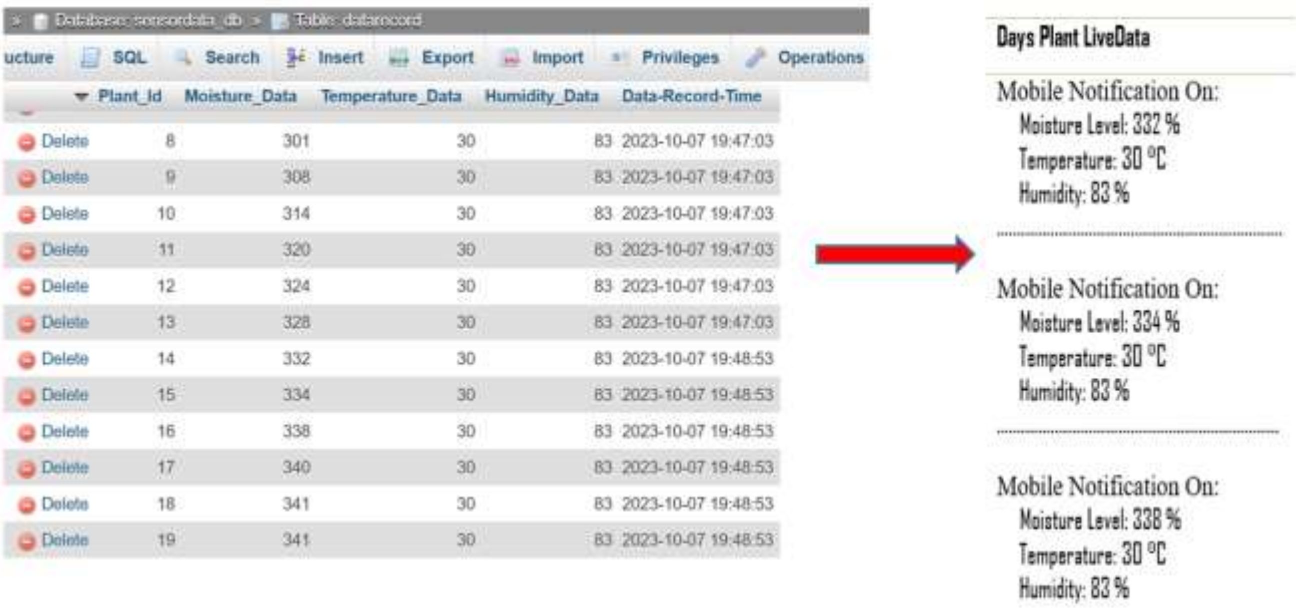



Figure 6. Sensor data values in the output monitor

This execution phase is crucial to explain since collected plants' live data were successfully retrieved from plants. Zoon now needs to transfer the data's original value as it is captured to the live database. We designed the MySQL database to catch sensor values from fields through communication channels. Cloud database is connected online via the xampp local server of the workstation computer. To automatically collect data in the local server, Apache and MySQL module action must start, and another function must not occupy the port. Figure 7 summarizes two vertical views of how agricultural live data are monitored by farmers or plant designers. Cloud servers hold live databases for plant data and self-directing update actions for holding considerable data in the server. Each data has an index as a denoted primary number. Data are captured, and that particular date and time are recorded in the database.

The second part of the following figure shows the farmer's front-end execution output of our research experiment. The farmers' Bluetooth app is paired with the ArduTooth HC 05 module. While farmers are not in the field or nearby, the paring feature can access plants' live data monitoring just using a smart mobile phone device. Farmers may attend to the mobile screen and decide what is necessary for plants and when they need more plant care.

Cloud server for plants lives database          Notification in farmers' mobile.




| | Plant_Id | Moisture_Data | Temperature_Data | Humidity_Data | Data-Record-Time |
|---|---|---|---|---|---|
| Delete | 8 | 301 | 30 | 83 | 2023-10-07 19:47:03 |
| Delete | 9 | 308 | 30 | 83 | 2023-10-07 19:47:03 |
| Delete | 10 | 314 | 30 | 83 | 2023-10-07 19:47:03 |
| Delete | 11 | 320 | 30 | 83 | 2023-10-07 19:47:03 |
| Delete | 12 | 324 | 30 | 83 | 2023-10-07 19:47:03 |
| Delete | 13 | 328 | 30 | 83 | 2023-10-07 19:47:03 |
| Delete | 14 | 332 | 30 | 83 | 2023-10-07 19:48:53 |
| Delete | 15 | 334 | 30 | 83 | 2023-10-07 19:48:53 |
| Delete | 16 | 338 | 30 | 83 | 2023-10-07 19:48:53 |
| Delete | 17 | 340 | 30 | 83 | 2023-10-07 19:48:53 |
| Delete | 18 | 341 | 30 | 83 | 2023-10-07 19:48:53 |
| Delete | 19 | 341 | 30 | 83 | 2023-10-07 19:48:53 |

Figure 7. Agricultural Live data monitoring

Farmer or plant designers get mobile notifications through IoT and cloud applications with existing online systems. The cloud server database collects live sensor data retrieved from root plants. PHP script implements code to transfer sensor data to farmers' mobile as a notification. On specified dates and times, plant designers/farmers explore plants' live data on hand, indicating today's plant data, such as soil moisture value of 332, the temperature at 30 $^{o}$c, and humidity at 83 per cent.

## CONCLUSIONS

Agricultural practice is changing and highly influenced to equip with sensor technology. Sensor technology with mobile applications assists farmers in continuing modern farming practices diversely and makes farmers aware of precision planting decisions in a more innovative way. This study implemented IoT sensor applications in agricultural live data collection. Live and accurate data from plants' root zone triggers computers or machines to execute necessary plant decisions. Virtually monitored data by farmers added new farming practices in the agricultural industry that resulted in modern and digital farming practices with technology. Farmers get all the necessary information about environmental effects on plants, which is vital in making fast and immediate plant decisions for field planting. This study also covered online cloud databases so that farmers can send plants live data or share it with experts for more solutions. Our research has a few limitations. It is applied to individual farmers' practices and field applications. However, in the future, we will expand our work so that the application model can be applied to industrial farming practices. Training functions will be arranged if necessary to make farmers-friendly use of sensor technology and smart mobile phone applications.

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## REFERENCES

Awan, S., Ahmed, S., Ullah, F., Nawaz, A., Khan, A., Uddin, M.I., Alharbi, A., Alosaimi, W., & Alyami, H. (2021). IoT with BlockChain: A Futuristic Approach in Agriculture and Food Supply Chain. *Wireless Communications and Mobile Computing*, 2021, pp. 1–14. https://doi.org/10.1155/2021/5580179

Basnet, B., & Bang. J.(2018).The State-of-the-Art of Knowledge-Intensive Agriculture: A Review on Applied Sensing Systems and Data Analytics. *Journal of Sensors*, 2018,1-13. https://doi.org/10.1155/2018/3528296

Dhanaraju, M., Chenniappan, P., Ramalingam, K., Pazhanivelan, S., & Kaliaperumal, R. (2022). Smart Farming: Internet of Things (IoT)-Based Sustainable Agriculture. *Agriculture*, 12(10), 1-16. https://doi.org/10.3390/agriculture12101745

Farooq, M.S., Riaz, S., Abid, A., Umer, T., & Zikria, Y. B. (2020). Role of IoT Technology in Agriculture: A Systematic Literature Review. *Electronics*, *9*(2), 1-41. https://doi.org/10.3390/electronics9020319

Jia, A. (2021). Intelligent garden planning and design based on the agricultural Internet of Things. *Complexity*, *2021*, 1–10. https://doi.org/10.1155/2021/9970160

Jurišić, M., Plaščak, I., & Željko, B., Radocaj, D., & Zimmer, D. (2021). Sensors and Their Application in Precision Agriculture. *Technical Journal (TG-TJ)*, *15*(4), 529-533. https://doi.org/10.31803/tg-20201015132216

Kayad, A., Paraforos, D. S., Marinello, F., & Fountas, S. (2020). Latest Advances in Sensor Applications in Agriculture. *Agriculture*, *10*(8), 1-8. https://doi.org/10.3390/agriculture10080362

Klerkx, L., Jakku, E., & Labarthe, P. (2019).A review of social science on digital agriculture, smart farming and agriculture 4.0: New contributions and a future research agenda. *NJAS: Wageningen Journal of Life Sciences*, *90*(1), 1-16. https://doi.org/10.1016/j.njas.2019.100315

Kilpatrick, S., & Johns, S. (2003). How farmers learn: Different approaches to change. *The Journal of Agricultural Education and Extension*, *9*(4), 151–164. https://doi.org/10.1080/13892240385300231

Nakhon, S. N., Keeratipranon, N., & Akarajariyakul, P. (2017) .Smart Planting Using Internet of Things Technology. *Topics in Economics, Business and Management (EBM)*, *1*(1), 373-377. http://doi.org/10.26480/icemi.01.2017.373.377

Obaideen, K., Yousef, B. A. A., AlMallahi, M. N., Tan, Y. C., Mahmouda, M., Jaber, H., & Ramadan, M. (2022). An overview of smart irrigation systems using IoT. *Energy Nexus*, *7*(1), 1-11. https://doi.org/10.1016/j.nexus.2022.100124

Pongnumkul, S., Chaovalit, P., & Surasvadi, N. (2015). Applications of Smartphone-Based Sensors in Agriculture: A Systematic Review of Research. *Journal of Sensors*, 2015, 1-18. https://doi.org/10.1155/2015/195308

Quddus, A., & Kropp, J. D. (2020). Constraints to Agricultural Production and Marketing in the Lagging Regions of Bangladesh. *Sustainability*, *12*(10), 1-24. https://doi.org/10.3390/su12103956

Ravi, A.K., & Gopal, C.S.R. (2017).SMART TECHNOLOGY IN FARMING DEVELOPMENT. *International Journal of Management (I.J.M.)*, *8*(2), 53–57. Retrieved from http://iaeme.com/Home/issue/IJM?Volume=8&Issue=2

Ragab, M. A., Badreldeen, M. M. M., Sedhom, A., & Mamdouh, W. M. (2022). I.O.T. based smart irrigation system. *International Journal of Industry and Sustainable Development, 3*(1), 76-86. https://doi.org/10.21608/ijisd.2022.148007.1021

Rubio, V.S., & Más, F.R. (2020). From Smart Farming towards Agriculture 5.0: A Review on Crop Data Management. *Agronomy*, *10*(2), 1-21. https://doi.org/10.3390/agronomy10020207

Tiwari, A., Singh, A.K., Kanth, N., & Pal, S. (2016). Computer Aided Designing for Landscape Gardening. *The Global Journal of Pharmaceutical Research, 5*(5), 386-388. Retrieved from https://www.researchgate.net/publication/311679804_Computer_Aided_Designing_for_Landscape_Gardening

Warren, M.(2004). Farmers online: drivers and impediments in adoption of internet in U.K. agricultural businesses. *Journal of Small Business Enterprise Development*, *11*(3), 371-381. https://doi.org/10.1108/14626000410551627

Wang, X.G., Lin, W., Zeng, W.H., & Zeng, W.(2010). Design and Key Technology of Gardening Information Management System Based on Data Center. *Journal of Geographic Information System*, *2*(2),100-105. https://doi.org/10.4236/jgis.2010.22015

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