Iot-Based Smart Agriculture Monitoring System

B Chandra kumar[1], Chaluvarayaswamy SG[2], Dhanush KN[3], Pavan A[4], Dr Manasa charitha[5]
[1,2,3,4]*Department of ECE, Vemana Institute of Technology, Bengaluru*
[5]*Assistant. Professor. Vemana Institute of technology*

***Abstract*—The work explains about the Internet of Things based Smart Agriculture Monitoring System developed for improving agricultural productivity and efficient farm management. The main aim of the system is to monitor important environmental and soil conditions in real time and automate irrigation processes to reduce human effort and water wastage. Different sensors, microcontrollers, wireless communication modules, and IoT technologies are used to collect and transmit agricultural data. This project reviews various smart farming techniques used in irrigation control, crop monitoring, greenhouse management, and environmental monitoring systems. From the reviewed studies, it is understood that integrating IoT with agriculture improves crop growth, saves water resources, and provides better decision-making support for farmers. Some challenges such as network connectivity issues, sensor accuracy, power management, and environmental disturbances still affect system performance. Future improvements can focus on increasing system reliability, enhancing real-time monitoring accuracy, and integrating advanced technologies like AI and cloud computing for smart farming applications.**

***Index Terms*—Smart Agriculture, IoT, Soil Moisture Sensor, Temperature Monitoring, Humidity Sensor, Automated Irrigation, Wireless Communication, Real-time Monitoring, Smart Farming, Embedded Systems**

I. INTRODUCTION

This work explains an Internet of Things based Smart Agriculture Monitoring System designed to improve farming efficiency through real-time monitoring and automation. The system uses sensors, microcontrollers, and wireless communication technologies to monitor soil moisture, temperature, humidity, and water levels for effective irrigation control. It helps reduce water wastage, minimize manual effort, and improve crop productivity. The survey reviews various smart farming methods used in irrigation, greenhouse monitoring, and precision agriculture applications. From the reviewed studies, it is observed that IoT integration improves agricultural performance and resource management. However, challenges such as sensor errors, network issues, and environmental disturbances still affect system accuracy and reliability.

II. LITERATURE SURVEY

This section reviews key contribution from recent advancements in low-cost IoT-based weather monitoring system designed for precision agriculture in India. Farmers often face crop losses because of unpredictable weather conditions such as changes in temperature, humidity, rainfall, and pressure. To solve this problem, the system collects real-time environmental data using sensors connected to an ESP32 microcontroller. The measured parameters include temperature, humidity, atmospheric pressure, light intensity, and rainfall. The collected data is displayed locally on an OLED display and also transmitted to the Thing Speak cloud platform through the internet for storage and visualization. The platform allows farmers to monitor weather conditions remotely and receive alerts when certain limits are crossed. Data analysis using MATLAB tools helps understand weather patterns and predict future conditions. The developed prototype successfully monitored weather parameters in real time and showed useful relationships between them. This low-cost system can help farmers make timely agricultural decisions, improve crop productivity, and reduce losses.

Maanak Gupta and his co-authors presented a low-cost IoT-based weather monitoring system for precision agriculture that helps farmers monitor environmental conditions in real time to reduce crop losses caused by unpredictable weather changes. The system uses sensors connected to an ESP32 microcontroller to measure parameters such as temperature, humidity, atmospheric pressure, light intensity, and rainfall. The collected data is displayed on an OLED screen and transmitted to the ThingSpeak cloud platform for remote monitoring, storage, and analysis. The system also provides alerts when environmental conditions cross predefined limits, helping farmers make timely decisions related to irrigation and crop management. Overall, the proposed IoT-based monitoring system improves agricultural productivity, supports precision farming, and reduces losses through real-time weather monitoring and cloud-based data analysis [1].

A. Naseer, M. Shmoon, T. Shakeel, S. Ur Rehman, A. Ahmad, and V. Gruhn presented an IoT-based Water Harvesting, Moisture Monitoring, and Crop Monitoring System for Precision Agriculture that helps farmers efficiently manage water resources and crop health using smart technologies. The system integrates sensors, an Arduino controller, Wi-Fi/GSM modules, and cloud computing to monitor soil moisture, water level, temperature, humidity, light intensity, and leaf wetness in real time. Sensor data is uploaded to the cloud for remote monitoring and analysis, enabling farmers to make informed irrigation and crop management decisions. The proposed system automatically controls a DC motor pump when soil moisture levels are low and stores excess rainwater for future use. It also provides alert notifications for abnormal conditions such as low moisture levels and animal intrusion. Experimental results showed successful monitoring of soil conditions with low, normal, and high moisture indications for irrigation control. The integration of IoT technology improves water usage efficiency, reduces manual labour, and enhances agricultural productivity, making it a low-cost and effective smart farming solution [2].

M. N. Mowla, N. Mowla, A. F. M. S. Shah, K. M. Rabie, and T. Shongwe proposed an IoT-based system for real-time monitoring of paddy growth that helps farmers efficiently manage agricultural activities using smart sensing technologies. The system uses multiple sensors to monitor important environmental parameters such as soil moisture, temperature, humidity, and water level in paddy fields. The collected sensor data is transmitted wirelessly to a cloud-based platform where it is analysed and displayed through graphs for better decision-making. The system supports smart irrigation methods such as drip irrigation and pump irrigation to maintain proper water levels and improve crop productivity. Experimental results showed continuous monitoring of environmental conditions with data storage and visualization through ThingSpeak graphs and Excel sheets for further analysis. The IoT-based monitoring system reduces manual labor, enables remote crop monitoring, minimizes water wastage, and supports sustainable farming practices. The sensors used in the system operate within typical ranges of temperature: 20 °C–35 °C, humidity: 40 %–90 %, soil moisture: 0 %–100 %, and water level: 0 cm–30 cm, making the system effective for precision agriculture and paddy cultivation. [3].

G. Mohyuddin, M. A. Khan, A. Haseeb, S. Mahpara, M. Waseem, and A. M. Saleh explained how IoT technologies are transforming traditional farming into smart agriculture systems by enabling real-time monitoring and automation of farming activities. Their study highlights the use of IoT devices, wireless sensor networks, and cloud platforms to collect and analyse important environmental parameters such as temperature, humidity, soil moisture, soil pH, and weather conditions. The system supports precision agriculture applications including weather monitoring, greenhouse monitoring, disease detection, and irrigation control to improve crop productivity and resource management. Sensor data is transmitted to smart control panels and cloud-based platforms for remote monitoring and decision-making. The authors also discussed that IoT-based smart agriculture systems help reduce labour costs, save water, minimize the use of fertilizers and pesticides, and increase agricultural yield. However, the study identified several challenges such as power consumption, network connectivity issues, hardware reliability, data security, and limited farmer awareness that affect large-scale implementation. The typical operating ranges discussed in the paper include temperature: 20 °C–32 °C, humidity: 70 %–80 %, soil moisture: 0 %–100 %, soil pH: 5.5–7.5, and air pressure: 950–1050 hPa. Overall, the proposed IoT applications in smart agriculture provide efficient farm monitoring, optimized resource utilization, and sustainable solutions to meet future food demands. [4].

V. P. Kour and S. Arora presented an IoT-Based Irrigation System for Smart Agriculture that enables real-time monitoring of soil and water conditions to improve irrigation efficiency and agricultural productivity. The system integrates sensors with an Arduino Uno R4 Wi-Fi microcontroller to measure important parameters such as soil moisture, pH level, and Total Dissolved Solids (TDS) in irrigation water. The collected sensor data is transmitted to the Arduino Cloud platform, where it is displayed on a dashboard for continuous monitoring and analysis by farmers. The proposed system helps farmers make accurate irrigation and nutrient management decisions by continuously analysing soil moisture and water quality conditions. The study also discusses advanced irrigation methods such as surface irrigation, drip irrigation, and sprinkler irrigation, which reduce water wastage and improve crop growth. A dataset of 500 sensor readings was analysed using machine learning techniques to classify irrigation conditions as good or bad for farming. The system additionally provides alerts to users whenever irrigation conditions change. The sensors used in the system include Soil Moisture Sensor, pH Sensor, and TDS Sensor with approximate operating ranges of TDS: 180–850 ppm, pH: 4.8–7.0, and soil moisture: 10%–50%. Overall, the IoT-based irrigation system improves water resource management, minimizes manual effort, and supports higher crop productivity through intelligent real-time monitoring and decision-making [5].

B. Yadeta, M. Ayana, M. Yitayew, and Tilahun Hordofa presented an IoT-Based Smart Control System for Monitoring Agriculture that uses Internet of Things (IoT) technology to monitor environmental conditions and improve farming efficiency. The system integrates multiple sensors with a microcontroller to measure important agricultural parameters such as soil moisture, temperature, humidity, rainfall, and soil temperature. The collected real-time data is transmitted to the Adafruit IO cloud platform, enabling farmers to remotely monitor field conditions and make informed decisions. The proposed system also includes weather forecasting through the Open Weather API, which helps predict rainfall and climate changes for better crop management. A smart irrigation mechanism automatically supplies water when soil moisture levels fall below the required threshold, thereby conserving water and improving irrigation efficiency. In addition, the system features an automatic roof shading mechanism controlled by a servo motor to protect crops from heavy rainfall. The sensors used in the system include Soil Moisture Sensor, DHT11 Temperature and Humidity Sensor, Rain Sensor, and DS18B20 Temperature Sensor, with operating ranges of temperature: −55 °C to 125 °C, humidity: 20 %–90 %, soil moisture: 0 %–100 %, and rain detection values from 0 (no rain) to 1 (rain detected). Overall, the IoT-based monitoring system reduces manual labour, improves crop productivity, saves water resources, and supports efficient smart farming practices [6].

D. A. Aziz, R. Asgarnezhad, M. S. Mustafa, A. A. Saber, and S. Alani presented an IoT-Based Real-Time Monitoring System for Precision Agriculture that uses Internet of Things (IoT) technology to monitor agricultural conditions and automate irrigation in real time. The system integrates a NodeMCU ESP8266 microcontroller with multiple sensors to collect environmental data such as soil moisture, temperature, and humidity from the farm. The collected data is transmitted wirelessly to the ThingSpeak cloud platform, allowing farmers to remotely monitor field conditions from anywhere. A capacitive soil moisture sensor continuously measures soil water levels and automatically controls irrigation through a relay-operated water pump. When soil moisture becomes low, the pump is activated to irrigate the crops, and it turns off automatically once adequate moisture is detected. The system also uses a DHT11 temperature and humidity sensor to monitor environmental conditions that influence crop growth, while a 0.96-inch OLED display shows real-time sensor readings locally. The proposed IoT-based monitoring system reduces manual labour, improves water management, and enhances crop productivity through automated irrigation and wireless monitoring. The sensors used in the system include a Capacitive Soil Moisture Sensor and DHT11 Temperature–Humidity Sensor with typical operating ranges of soil moisture: 0%–100%, temperature: 0 °C–50 °C, and humidity: 20%–90%. Overall, the system supports precision agriculture, sustainable farming practices, and efficient resource management by providing real-time monitoring and automatic control of water supply [7].

F. K. Shaikh, S. Karim, S. Zeadally, and J. Nebhen presented an IoT Assisted Smart Agriculture Monitoring and Summarization System using NodeMCU and Efficient Sensor Unit to improve farming efficiency and crop productivity through real-time monitoring and intelligent automation. The system integrates NodeMCU ESP8266, agricultural drones, and multiple sensors such as soil moisture sensors, optical sensors, motion sensors, and temperature–humidity sensors to collect important agricultural data from the field. The collected data is transmitted through Wi-Fi to cloud platforms like AWS and Azure, where it is analysed using machine learning algorithms to provide useful insights for farmers. Farmers can access real-time information, alerts, and recommendations through a dashboard for better crop management and decision-making. The system also supports automatic irrigation control based on soil moisture levels, helping reduce water wastage and improve resource utilization. According to the soil moisture dataset presented in the study, sensor readings ranged approximately from 29% to 42% during the observation period, while environmental conditions monitored included temperature values of about 20 °C–40 °C and humidity levels around 30%–90%. Optical sensor readings used for crop observation ranged approximately from 1150 to 1240 units. Overall, the IoT-based smart agriculture monitoring system reduces manual labour, improves water efficiency, enhances crop yield, and supports sustainable precision farming practices through real-time monitoring and data-driven automation [8].

Mohamed, E.S., Belal, A.A., Abd-Elmabod, S.K., El-Shirbeny, M.A., Gad, A. and Zahran, M.B.,"Smart The system also supports automatic irrigation control based on soil moisture levels, helping reduce water wastage and improve resource utilization. According to the soil moisture dataset presented in the study, sensor readings ranged approximately from 29% to 42% during the observation period, while environmental conditions monitored included temperature values of about 20 °C–40 °C and humidity levels around 30%–90%. Optical sensor readings used for crop observation ranged approximately from 1150 to 1240 units. Overall, the IoT-based smart agriculture monitoring system reduces manual labour, improves water efficiency, enhances crop yield, and supports sustainable precision farming practices through real-time monitoring and data-driven automation farming for improving agricultural management",2021 [9].

III. RESEARCH GAP

From the reviewed literature, it is observed that Internet of Things based Smart Agriculture Monitoring System mainly focus on improving agricultural productivity through real-time monitoring, automation, and efficient resource management. The studies explain the use of various sensors such as soil moisture, temperature, humidity, rainfall, water level, pH, TDS, and soil mineral sensors integrated with microcontrollers like Arduino, ESP32, NodeMCU, and wireless communication technologies for smart farming applications. Most systems use cloud platforms such as Thing Speak, Adafruit IO, AWS, and Arduino Cloud for remote monitoring, data storage, and analysis. The reviewed papers also discuss automated irrigation control, weather monitoring, rainwater harvesting, greenhouse management, crop health monitoring, and precision agriculture techniques to reduce water wastage and manual labor while improving crop yield. Some systems additionally use machine learning, weather forecasting APIs, drones, and alert mechanisms to support intelligent decision-making and real-time agricultural management. From the reviewed studies, it is observed that IoT integration in agriculture provides better monitoring accuracy, efficient water management, sustainable farming practices, and improved productivity. However, challenges such as network connectivity issues, sensor inaccuracies, power consumption, environmental disturbances, hardware reliability, and data security still affect system performance and large-scale implementation. Overall, the reviewed papers demonstrate that IoT-based smart agriculture systems offer cost-effective, automated, and efficient solutions for modern farming and can significantly contribute to sustainable agricultural development in the future.

IV. RELATED WORK

The proposed work focuses on recent advancements in IoT-based smart agriculture monitoring systems for efficient farm management and precision agriculture. The survey analyses various agricultural monitoring techniques that use wireless sensors, cloud platforms, automation systems, and smart communication technologies for real-time monitoring of environmental and soil conditions. It also reviews systems involving automated irrigation, weather monitoring, crop health monitoring, water management, and intelligent decision-making integrated with IoT and cloud computing technologies. The survey aims to compare existing methodologies, identify research gaps, and evaluate the performance of different smart agriculture systems in terms of water efficiency, crop productivity, remote monitoring, automation, reliability, and resource optimization. Additionally, the survey highlights future trends and emerging applications of IoT-enabled smart farming systems for sustainable agriculture and modern precision farming practices.

V. PROPOSED METHODOLOGY

The proposed methodology is based on an IoT-enabled smart agriculture monitoring system for real-time monitoring and automatic irrigation control. At the sensing side, environmental and soil data are collected using sensors that measure parameters such as soil moisture, temperature, humidity, and water level from the agricultural field. The collected sensor data is sent to the NodeMCU/ESP8266 or Arduino microcontroller for processing and analysis. The microcontroller transmits the data to a cloud platform through Wi-Fi communication, where farmers can remotely monitor field conditions using a mobile device or web dashboard. Based on the soil moisture level, the system automatically controls a water pump through a relay module to provide irrigation when the soil becomes dry and stops the pump when sufficient moisture is detected. Additional features such as weather monitoring, alert notifications, and real-time data visualization improve decision-making and resource management. This methodology ensures efficient water usage, reduced manual labour, continuous crop monitoring, and improved agricultural productivity through smart IoT-based automation.

VI. ADVANTAGES & LIMITATIONS

IOT-based smart agriculture monitoring systems offer several advantages over traditional farming methods. These systems provide real-time monitoring of environmental conditions such as soil moisture, temperature, humidity, and water level, helping farmers make accurate decisions about irrigation and crop management. Automated irrigation control improves water usage efficiency, reduces water wastage, and minimizes manual labour. Cloud-based monitoring and wireless communication allow farmers to remotely access farm data and receive alerts about abnormal conditions, improving productivity and resource management. In addition, IoT-based agriculture systems support precision farming, sustainable agriculture, and efficient crop monitoring through continuous data collection and intelligent automation. However, these systems also have certain limitations. IoT-based agriculture systems depend heavily on stable internet connectivity and power supply for continuous operation. Sensor accuracy may be affected by environmental conditions such as dust, rain, or extreme temperatures, leading to inaccurate readings. Initial setup and maintenance costs can be high for small-scale farmers, and data security or privacy issues may arise due to cloud-based communication. Moreover, technical complexity and lack of awareness among farmers can limit the adoption of smart agriculture technologies in rural areas.

VII. FUTURE SCOPE

IOT-based smart agriculture monitoring systems have significant future potential due to the increasing demand for smart farming, efficient water management, and sustainable agricultural practices. Future research can focus on improving sensor accuracy, low-power communication, and intelligent automation techniques to enhance system reliability and performance. Integration of IoT systems with Artificial Intelligence (AI), Machine Learning (ML), cloud computing, and 5G technologies can enable advanced crop prediction, disease detection, and automated decision-making for precision agriculture. Advanced data analytics and smart forecasting techniques can further improve irrigation management, crop monitoring, and resource optimization. Researchers can also explore applications such as drone-based crop monitoring, smart greenhouse systems, livestock monitoring, and automated fertilizer management. In addition, the development of solar-powered and energy-efficient IoT devices can support sustainable farming solutions and enable smart agriculture systems to operate effectively in remote and rural areas.

VIII. CONCLUSION

The reviewed papers on the Internet of Things based Smart Agriculture Monitoring System show that IoT technologies improve farming efficiency through real-time monitoring, automated irrigation, and smart crop management. The use of sensors, microcontrollers, and cloud platforms helps reduce water wastage, minimize manual effort, and increase crop productivity. The studies also highlight the importance of smart farming in supporting sustainable agriculture and better resource management. However, challenges such as network issues, sensor errors, power consumption, and environmental conditions still affect system performance and reliability.

REFERENCES

[1] Maanak Gupta et al.,"Security and Privacy in Smart Farming: Challenges and Opportunities", 2020.
[2] A. Naseer, M. Shmoon, T. Shakeel, S. Ur Rehman, A. Ahmad and V. Gruhn, "A Systematic Literature Review of the IoT in Agriculture—Global Adoption, Innovations, Security, and Privacy Challenges," 2024.
[3] M. N. Mowla, N. Mowla, A. F. M. S. Shah, K. M. Rabie and T. Shongwe, "Internet of Things and Wireless Sensor Networks for Smart Agriculture Applications: A Survey, 2023.
[4] G. Mohyuddin, M. A. Khan, A. Haseeb, S. Mahpara, M. Waseem and A. M. Saleh, "Evaluation of Machine Learning Approaches for Precision Farming in Smart Agriculture System: A Comprehensive Review,", 2024.
[5] V. P. Kour and S. Arora, "Recent Developments of the Internet of Things in Agriculture: A Survey," 2020.
[6] B. Yadeta, M. Ayana, M. Yitayew, and Tilahun Hordofa, "Performance evaluation of furrow irrigation water management practice under Wonji Shoa Sugar Estate condition, in Central Ethiopia",2022.
[7] Aziz, D.A., Asgarnezhad, R., Mustafa, M.S., Saber, A.A. and Alani, S.. "A Developed IoT Platform-Based Data Repository for Smart Farming Applications",2023.
[8] Shaikh, F.K., Karim, S., Zeadally, S. and Nebhen, J., "Recent Trends in Internet of Things enabled Sensor Technologies for Smart", Agriculture,2022.
[9] Mohamed, E.S., Belal, A.A., Abd-Elmabod, S.K., El-Shirbeny, M.A., Gad, A. and Zahran, M.B.,"Smart farming for improving agricultural management",2021.