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IoT-Based Smart Farming System for Climate-Resilient Agriculture

Fardeen Rahman
Department of CSE
Apex Institute of Technology
Chandigarh University
Mohali, Punjab, India
21BCS6912@cuchd.in

S. Vignesh
Department of CSE
Apex Institute of Technology
Chandigarh University
Mohali, Punjab, India
21BCS6891@cuchd.in

Saurav Bhatt
Department of CSE
Apex Institute of Technology
Chandigarh University
Mohali, Punjab, India
21BCS6890@cuchd.in

U. Hariharan
Department of CSE
Apex Institute of Technology
Chandigarh University
Mohali, Punjab, India
hariharan.e11201@cuchd.in

***Abstract*—Over the last ten years, climate shifts and inconsistent rainfall patterns have been evident. As a result, many farmers in India have begun to implement climate-smart approaches known as smart agriculture. An essential aspect of smart agriculture is the Internet of Things (IoT), which plays a significant role in minimizing water and fertilizer waste while boosting crop production. This automated information technology utilizes IoT to improve agricultural practices. As IoT continues to evolve, its applications have become increasingly prevalent in various wireless settings. This project explores and reviews the integration of sensor technology and wireless networks within IoT, focusing on the current agricultural landscape. The study includes a temperature sensor, humidity sensor, and rain sensor, which measure temperature and soil moisture levels. A combined strategy involving internet connectivity and wireless communication is proposed through a Remote Monitoring System (RMS). The primary aim is to gather real-time data regarding the agricultural production environment, facilitating better access for farming practices and enhancing crop yields. By monitoring the farmland via the IP address, deficiencies in soil nutrients can be identified and addressed.**

***Key words*—: Internet of things, Wireless sensor network, Arduino, Smart agriculture, Sensors, Moisture, Temperature, Humidity**

I. Introduction

Agriculture, rooted in the Latin words ”Ager” (land or field) and ”Culture” (cultivation), represents the science and art of cultivating crops and raising livestock for economic purposes. It involves utilizing soil to grow vegetation that benefits humanity and is a cornerstone of human civilization, enabling communities to establish permanent settlements. As one of the earliest activities undertaken by humans, agriculture remains a fundamental livelihood source. Despite the global shift toward industrialization and urbanization, nearly half of the global workforce is still engaged in agricultural activities. In developing nations, agriculture is a key driver of employment and significantly impacts the economy. Its primary goal is to cultivate high-quality and productive crops by enhancing growth through improved soil management and water availability. In India, agriculture serves as the backbone of the economy, with nearly 64Across the world, agricultural activities are shaped by physical factors, and this is especially true for India. The country faces two significant challenges in agriculture: meeting the growing food requirements of its increasing population and addressing the uneven development of agricultural practices and land usage. Over the years, India has made consistent efforts to achieve self-reliance in agriculture, particularly through its five-year plans. Since independence, agriculture has received priority in these plans due to its vital importance. After 1950, the geographic study of land and agriculture gained attention, and by the 1970s, the Green Revolution introduced transformative changes. This revolution enabled India not only to become self-sufficient in food grain production but also to export small quantities.

However, the growth of agriculture has been hindered by disorganized practices, unreliable rainfall, inadequate infrastructure, and unequal distribution of resources. The Green Revolution’s success was largely confined to irrigated regions, leaving many small farmers unable to benefit significantly. This led to a growing divide between small and large landowners. Bridging this gap requires strategic planning, supported by detailed regional data. In India, where a significant portion of the population depends on agriculture, a considerable share of national income stems from agricultural activities. Despite advancements in technology, many agricultural methods remain traditional, such as manual seed sowing, cultivating two crops annually, and using outdated farming techniques. Irregular monsoons and inconsistent water availability further complicate efforts, resulting in poor yields and low productivity. The adoption of scientific approaches can significantly improve farming methods and crop productivity. Innovations such as the Internet of Things offer new opportunities to revolutionize agricultural practices. For instance, wireless sensor networks

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can collect data from fields and transmit it to centralized systems for analysis. This data can help monitor environmental conditions to improve crop yields. However, focusing solely on environmental factors is insufficient, as other variables also play a critical role in enhancing agricultural productivity.

II. Literature Survey

[1] A sustainable agriculture system that uses IoT technology to automate agricultural field monitoring is discussed by Ramya Venkatesan and Anandhi Tamilvanan. The suggested solution uses a Raspberry Pi camera to feed live video, allowing for field surveillance in real time. Using the proper sensors, environmental parameters including temperature, humidity, and soil moisture are tracked. While guaranteeing the safe long-term preservation of agricultural data on cloud platforms, the integration of IoT and wireless sensor nodes minimizes the amount of manual labor required for field observation. Better crop yields and optimum agricultural practices are ensured by this system's continual monitoring, especially in crucial areas.This approach enables remote decision-making, which is particularly useful for large-scale and inaccessible farms.

[2] To improve farming efficiency, K. Lakshmisudha, Swathi Hegde, Neha Kale, and Shruti Iyer suggest a precision agriculture system that uses sensors. In order to assess environmental conditions and maximize resource utilization, the model incorporates temperature sensors, soil moisture sensors, and additional monitoring equipment. By emphasizing accuracy in farming practices, the approach enables farmers to make well-informed choices about pest management, fertilization, and irrigation. The strategy lowers waste and boosts overall productivity by using IoT for real-time data collecting and analysis.It also provides insights that can guide future planning and reduce environmental impact.

[3] IoT and smart agriculture are combined in a model presented by Nikesh Gondchawar and Prof. Dr. R.S. Kawitkar to improve conventional farming methods. While automating procedures like fertilization and watering, their system keeps an eye on a number of variables, including soil moisture, temperature, and humidity. Wireless networks are used to transfer the gathered data to a centralized system, where it is examined to extract useful information. This model tackles the issues brought on by climatic variability and shifting agricultural conditions while ensuring resource efficiency and minimizing physical labor.This integration helps to predict crop health trends and improve operational decisions.

[4] In order to increase productivity, M.K. Gayatri, J. Jayasakthi, and Dr. G.S. Anandhamala concentrate on creating smart agriculture solutions with IoT. Real-time monitoring of environmental factors, crop health, and soil conditions is part of their approach. It makes it possible for farmers to use data-driven strategies for pest control, fertilization, and irrigation. Better decision-making, increased yields, and lower costs are made possible by the incorporation of IoT technology, which eventually improves farmers' financial stability.The system also supports sustainable agriculture by optimizing input usage.

[5] The sensor-based smart farming system that Chetan Dwarkani M, Ganesh Ram R, Jagannathan S, and R. Priyadharshini suggest is intended to automate agricultural operations. The system combines automation technologies for irrigation and pesticide spraying with sensors for temperature, humidity, and soil moisture monitoring. The framework guarantees the best possible use of resources, enhances crop management, and minimizes human interference. Additionally, it tackles issues like pest outbreaks and erratic weather, which increases sustainability and output.Its automation capabilities reduce labor dependency and enhance operational efficiency.

[6] G. Sivanageswar Rao, A. Anusha, A. Gupta, and Ravi Kumar Tenali provide a paradigm that integrates smart agriculture and IoT to update farming methods. Critical parameters including soil pH, moisture content, and ambient temperature are tracked by the system using sensors. Farmers can increase productivity and yields by making well-informed decisions with the aid of real-time data transmission and analysis. This strategy tackles issues like pest infestations and climate variability while guaranteeing resource utilization.It offers flexibility to adapt the system for various types of crops and terrains.

[7] M.P. Jhothi, Anupama Hongal, and Prathibha S.R. create an Internet of Things-based monitoring system to improve agricultural output. Their model monitors soil conditions, temperature, and humidity by combining conventional farming practices with contemporary IoT technologies. By offering real-time data analysis, the system empowers farmers to take proactive approaches to crop management. Better yields at lower prices are guaranteed when traditional knowledge and cutting-edge technologies are combined, making it affordable for farmers in rural regions.The hybrid model bridges the digital divide, making tech solutions more inclusive.

[8] Using the Internet of Things, Dr. Sanjay N. Patil and Madhuri B. Jadhav demonstrate a smart agriculture monitoring system that allows for real-time agricultural activity observation. The system uses sensors to track environmental and soil conditions, and data is sent over Internet of Things platforms. Farmers can access the information via web interfaces or mobile apps, guaranteeing efficiency and ease. This strategy encourages sustainable farming methods, improves resource use, and lessens manual labor.Its user-friendly interface ensures accessibility even for farmers with minimal technical skills.

[9] N.R. Kale and Prof. K.A. Patil present a smart agriculture model that emphasizes the effects of rainfall abnormalities and climate change. In order to track agricultural characteris-

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tics including soil moisture, temperature, and humidity, their system incorporates sensors. In order to maximize agricultural productivity and assist farmers in adjusting to shifting weather patterns, the gathered data is examined. This strategy promotes sustainable farming methods and improves resource management.The model can serve as an early warning system for climate-sensitive crops.

TABLE I
SUMMARY OF LITERATURE SURVEY ON IOT-BASED SMART AGRICULTURE SYSTEMS

Ref	Authors	Technology Used	Parameters Monitored	Key Contributions
[1]	Ramya Venkatesan, Anandhi Tamilvanan	Raspberry Pi, Cloud, Sensors	Temp, Humidity, Soil Moisture, Live Feed	Real-time surveillance and remote monitoring with data storage in the cloud
[2]	K. Lakshmisudha et al.	IoT, Sensors	Temp, Soil Moisture	Precision farming and optimized resource usage
[3]	Nikesh Gondchawar, Dr. R.S. Kawitkar	Wireless Networks, IoT	Temp, Humidity, Soil Moisture	Automation of irrigation and fertilization; centralized data analysis
[4]	M.K. Gayatri et al.	IoT	Environmental and crop data	Data-driven pest control, irrigation, and fertilization
[5]	Chetan Dwarkani M et al.	IoT, Automation Systems	Temp, Humidity, Soil Moisture	Automated irrigation and pest control for sustainability
[6]	G. Sivanageswar Rao et al.	IoT, Sensors	Soil pH, Moisture, Temperature	Real-time data analysis for resource optimization
[7]	M.P. Jhothi et al.	IoT	Temp, Humidity, Soil Conditions	Cost-effective monitoring for rural farmers
[8]	Dr. Sanjay N. Patil, Madhuri B. Jadhav	IoT, Web/Mobile Apps	Environmental and Soil Data	Accessible monitoring via app/web interfaces
[9]	N.R. Kale, Prof. K.A. Patil	IoT	Temp, Humidity, Soil Moisture	Tackles climate variability and rainfall irregularities

III. PROPOSED METHODOLOGY

IoT technology is used in the suggested system to create a comprehensive smart agricultural monitoring and control system. It reduces the need for human intervention by automating crucial farming tasks including crop protection and irrigation, with the goal of increasing efficiency, sustainability, and crop output. This cutting-edge technology includes safeguards against environmental hazards including intense sunlight, heavy rain, storms, and wildlife threats, as well as real-time tracking of vital soil and environmental parameters like temperature, humidity, and moisture.

The ESP32 microcontroller, which is at the heart of the system, provides robust processing power and smooth Internet of Things integration with its integrated Bluetooth and Wi-Fi. The ESP32 facilitates remote communication with an Internet of Things web server while processing data from several sensors and actuators. Sensors such as the DHT11, soil moisture sensor, and rain sensor are used to measure important environmental data. The DHT11 is a cost-effective, precise sensor that measures humidity levels from 20This system's automated greenhouse shade, which shields crops from intense heat and sunlight, is a noteworthy feature. In order to provide the best growth circumstances for the crops, the shade is controlled by light and temperature sensors and retracts or deploys using servo motors. Additionally, when there is a threat from wildlife, storms, or severe rain, the protective shade is automatically activated. By reacting to signals from the rain sensor, soil saturation data, or motion detection devices, this shade protects crops from threats to the environment and wildlife.

The arrangement also includes an automated irrigation system that is managed by a water pump and a relay module. Real-time soil moisture monitoring trigger the water pump, which maximizes water use and supplies steady hydration for robust crop growth. A 16x2 LCD display allows farmers to keep an eye on the entire system locally. It shows real-time data on temperature, humidity, soil moisture, and the state of irrigation and shading. The IoT web server facilitates remote monitoring and management via mobile and online applications, giving farmers real-time alerts about important events such as excessive sunlight, precipitation, or possible wildlife incursion. Farmers may now make changes from anywhere because to this connectivity, which increases flexibility and monitoring.

The components of the system work together to produce exceptional outcomes. Efficient data processing and transmission with sensors and actuators are guaranteed by the ESP32 microcontroller. The soil moisture sensor ensures precise water distribution to crops, while the DHT11 sensor monitors the surrounding temperature and humidity. When it rains a lot, the rain sensor starts precautionary actions to avoid waterlogging. To guarantee dependable crop protection, the greenhouse and protective shades are driven by servo or stepper motors and react immediately to climatic cues. Effective watering is made possible by the relay module and water pump, and the LCD display shows the system's status on-site. Remote access and management are made possible via the IoT web server, which

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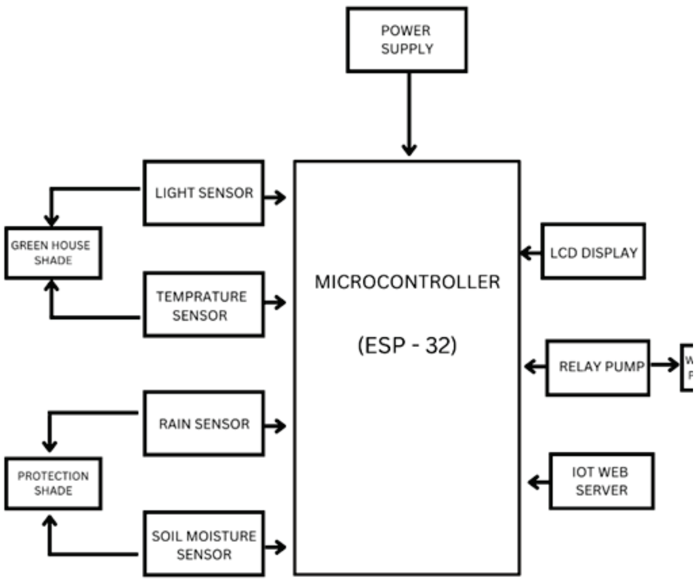

Fig. 1. Smart Agriculture System using IOT outline

can be hosted on the ESP32 or coupled with cloud services like AWS IoT or ThingSpeak. This feature makes the system incredibly flexible.

IV. Implementation

The system uses the Internet of Things (IoT) to track and manage important agricultural variables. In addition to automating watering, shielding crops from unfavorable environmental conditions, and promoting sustainability, it lessens the need for human intervention. Notable features include real-time soil and environmental parameter monitoring, automated shading, protection from storms and wildlife, and remote control through Internet of Things connectivity. With the help of precise, real-time data collected from several sensors, the system helps farmers to receive alerts and make well-informed decisions. These sensors enable accurate resource allocation by continuously monitoring temperature, humidity, soil moisture, and rainfall.Additionally, remote access is guaranteed by the interface with online and mobile platforms, providing farmers with the freedom to manage their fields from any location at any time. This reduces crop loss from unforeseen weather or soil changes while also increasing efficiency. All things considered, the system is a big step toward precision, data-driven agriculture that promotes environmental responsibility and production.

A. Key Components

1) **Microcontroller (ESP32)**
This acts as the system's central unit, coordinating sensors, actuators, and IoT communication. It is equipped with a dual-core processor, capabilities for Wi-Fi and Bluetooth, along with 34 GPIO pins.

Fig. 2. Microcontroller (ESP32)

2) **Temperature and Humidity Sensor (DHT11)**
This device reliably measures the surrounding temperature and humidity levels.

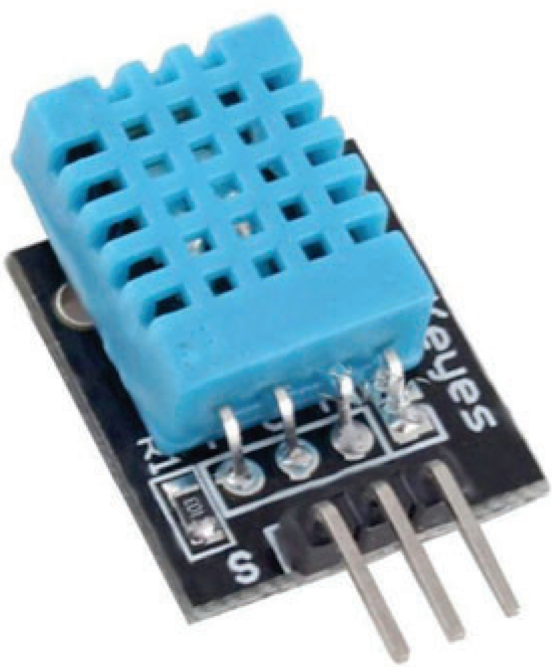

Fig. 3. Temperature and Humidity Sensor (DHT11)

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3) **Soil Moisture Sensor**
This advanced sensor accurately measures soil moisture levels to automate irrigation processes, ensuring optimal water usage and significantly improving overall water efficiency in agricultural and gardening applications.

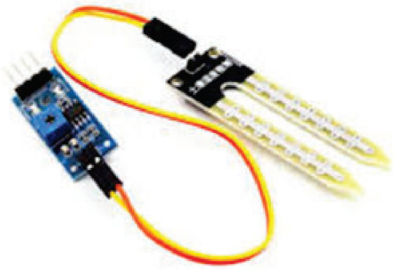

Fig. 4. Soil Moisture Sensor

4) **Rain Sensor**
This device detects rain and activates protective features such as shades to prevent soil saturation.

Fig. 5. Rain Sensor

5) **LCD Display (16x2)**
This display shows real-time data regarding temperature, humidity, and system performance for on-site observation.

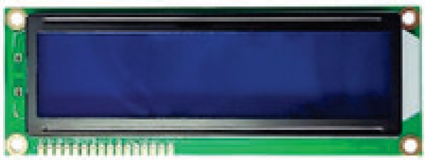

Fig. 6. LCD Display (16x2)

6) **Relay and Motor Pump**
The relay operates the water pump based on moisture readings from the soil sensor, ensuring effective irrigation.

Fig. 7. Relay and Motor Pump

V. Results

Using IoT technology, the Smart Agricultural Monitoring and Control System provides real-time administration, automation, and supervision to address modern farming challenges. This innovative system seeks to promote sustainable agricultural practices by increasing crop productivity, decreasing

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the need for human labor, and improving resource efficiency. It gives farmers accurate tools for efficient crop cultivation by combining automated environmental observation, irrigation control, and Internet of Things connectivity. Monitoring vital soil and environmental parameters including temperature, humidity, and soil moisture is at the core of the system. The ESP32 microcontroller analyzes the data that is continuously collected by automated sensors. This makes it possible to make well-informed decisions about things like adjusting irrigation levels or applying protective shades according to the weather. A soil moisture sensor determines when watering is necessary, while a DHT11 sensor measures temperature and humidity. Additionally, a rain sensor increases the system's adaptability by detecting rainfall and turning on safeguards against storms or too much water damaging crops. The device uses servo motors to automatically operate a greenhouse shade and a protective cover to protect crops from harsh weather conditions. While the protective cover guards against intense rains or animal invasions, the greenhouse shade adapts to avoid too much sunlight or heat exposure. By giving real-time data on temperature, soil moisture content, and the state of shadow deployment, an LCD display makes on-site monitoring easier. Through web or mobile applications, remote management and supervision are made possible by the inclusion of IoT connectivity. In addition to viewing up-to-date statistics, farmers can get alerts concerning important occurrences like sudden rain or the presence of wildlife. Accurate field environmental condition monitoring is further facilitated by the system's GPS module. Furthermore, a relay module automates the irrigation system by controlling the water pump in response to soil moisture readings, maximizing water use and preventing over-irrigation. By combining automation, IoT connection, and ongoing monitoring to promote sustainable agricultural methods, this project represents a significant advancement in precision agriculture. The technology equips farmers with the tools they need to successfully address today's agricultural issues by automating critical processes and providing remote access.

VI. Conclusion

A game-changing invention that aims to change contemporary farming methods is the Smart Agricultural Monitoring and Control System. This system offers a complete and intelligent solution for accurate, efficient, and sustainable agriculture by combining cutting-edge sensors, automation, and real-time environmental monitoring. It successfully connects conventional farming practices with the needs of the modern, climate-challenged planet.IoT connection, which facilitates smooth communication between sensors, actuators, and distant platforms, is at the core of the system. Farmers are better equipped to make timely, well-informed decisions about protecting the environment, using water, and caring for their crops. This results in better crop health, reduced waste, and optimal resource use. The technology gives farmers the ability to monitor and manage their crops remotely from any location using computers or cellphones, increasing flexibility and decreasing the need for manual labor.

Crops are nourished in ideal conditions throughout their growth cycle thanks to the system's primary features, which include automated watering, intelligent shade to shield crops from inclement weather, and alarms for rain, wildlife intrusion, or unusual conditions. Moreover, accurate reactions to environmental changes are made possible by soil moisture sensors, temperature and humidity monitoring, and rain detection. An important step in creating a smart and resilient agricultural environment is this initiative. In addition to increasing output and decreasing the need for physical labor, it also promotes environmentally friendly farming practices by encouraging prudent use of energy and water. The technology facilitates ongoing environmental monitoring and data-driven decision-making, which promotes long-term agricultural sustainability. Essentially, it establishes the groundwork for an agricultural future that is both technologically sophisticated and ecologically conscious, guaranteeing both food security and financial stability for farming communities.

References

[1] Ramya Venkatesan and Anandhi Tamilvanan, "A Sustainable Agriculture System Using IOT", International Conference on Communication and Signal Processing, April 6-8, 2017.

[2] K. Lakshmisudha, Swathi Hegde, Neha Kale, Shruti Iyer, "Smart Precision Based Agriculture Using Sensors", International Journal of Computer Applications (0975-8887), Volume 146 No.11, July 2011.

[3] Nikesh Gondchawar, Prof. Dr. R.S. Kawitkar, "IoT Based Smart Agriculture", International Journal of Advanced Research in Computer and Communication Engineering (IJARCCE), Vol.5, Issue 6, June 2016.

[4] M.K. Gayatri, J. Jayasakthi, Dr. G.S. Anandhamala, "Providing Smart Agriculture Solutions to Farmers for Better Yielding Using IOT", IEEE International Conference on Technological Innovations in ICT for Agriculture and Rural Development.

[5] Chetan Dwarkani M, Ganesh Ram R, Jagannathan S, R. Priyadharshini, "Smart Farming System Using Sensors for Agricultural Task Automation", IEEE International Conference on Technological Innovations in ICT for Agriculture and Rural Development (TIAR 2015).

[6] A. Anusha, A. Guptha, G. Sivanageswar Rao, Ravi Kumar Tenali, "A Model for Smart Agriculture using IOT", International Journal of Innovative Technology and Exploring Engineering, ISSN:2278-3075, April-2019.

[7] Prathibha S R, Anupama Hongal, Jhothi M, "IOT Based Monitoring System in Smart Agriculture", International Conference on Recent Advances in Electronics and Communication Technology, 2017.

[8] Dr. Sanjay N Patil, Madhuri B Jadhav, "Smart Agriculture Monitoring System using IOT", International Journal of Advanced Research in Computer and Communication Engineering, April-4, 2019.

[9] Prof. K A Patil, N R Kale, "A Model for Smart Agriculture using IOT", International Conference on Global Trends in Signal Processing, Information Computing and Communication, 2016.