Usha S, 2026, 14:2
ISSN (Online): 2348-4098
ISSN (Print): 2395-4752

International Journal of Science,
Engineering and Technology
An Open Access Journal

Smart Farming with Sensors and Automated Pest Control

Usha S, Kanishkar S K, Nishanth K, Ramakrishnan R, Sakthi S
Department of Electronics and Communication Engineering, Paavai Engineering college, Namakkal- 637018

Abstract— The integration of sensor technologies and automated pest control systems is revolutionizing modern agriculture, ushering in a new era of smart farming. This approach leverages Internet of Things (IoT) devices, such as soil moisture sensors, temperature and humidity monitors, and multispectral imaging, to collect real-time data on crop health and environmental conditions. These insights enable precision agriculture practices, optimizing irrigation, fertilization, and pest management strategies.

Index Terms— Smart farming,Precision Agriculture,Internet of Things (IoT) in Agriculture,Agricultural Sensors,Automated Pest Control,Wireless Sensor Networks (WSN),Crop Monitoring,Pest Detection Systems,Data-Driven Farming,Sustainable Agriculture,Smart Irrigation,Remote Sensing,AI in Agriculture,Environmental Monitoring,AgriTech solutions.

I. INTRODUCTION

Agriculture is undergoing a transformative shift with the advent of smart technologies that promise to enhance productivity, sustainability, and resilience. Among these innovations, sensor-based monitoring and automated pest control systems stand out as pivotal tools in modern farming. Traditional agricultural practices often rely on manual observation and blanket pesticide application, which can lead to inefficiencies, environmental degradation, and increased costs.

Smart farming leverages Internet of Things (IoT) devices, wireless sensor networks, and data analytics to monitor soil conditions, crop health, and environmental factors in real time. These sensors provide granular insights that enable farmers to make informed decisions about irrigation, fertilization, and pest management. Automated pest control systems—such as AI-powered drones, smart traps, and precision sprayers—respond dynamically to pest threats, applying targeted treatments only when and where needed.

This integration of sensing and automation not only reduces chemical usage and labor demands but also improves crop yields and promotes ecological balance. As global food demand rises and climate challenges intensify, smart farming with sensors and automated pest control offers a scalable, data-driven solution to ensure agricultural sustainability and food security.

II. LITEREATURE REVIEW

Review Stage

At the review stage, the study titled "Climate-Smart Agriculture: Adoption, Impacts, and Implications for Sustainable Development" by Wanglin Ma and Dil Bahadur Rahut provides an in-depth analysis of how climate-smart agricultural (CSA) practices are being adopted across different regions and their effects on sustainability. The authors systematically review various CSA techniques—such as improved irrigation, drought-resistant crops, conservation tillage, and integrated pest management—and examine their role in enhancing agricultural productivity, building climate resilience, and reducing greenhouse gas emissions. Through an extensive review of empirical studies, the paper highlights the socio-economic and institutional factors that influence farmers' decisions to adopt CSA, including access to information, market support, and government policies. The review also explores the broader implications of CSA for food security, poverty reduction, and environmental conservation. By synthesizing existing literature, the study lays a foundation for understanding the effectiveness and challenges of climate-smart agriculture in achieving long-term sustainable development goals [1].

At the review stage, the paper titled "Internet of Things for the Future of Smart Agriculture: A Comprehensive Survey of Emerging Technologies" by Othmane Friha, Mohamed Amine Ferrag, Lei Shu, Leandros Maglaras, and Xiaochan Wang provides a detailed and structured literature review of how IoT technologies are revolutionizing smart agriculture. The authors examine a wide range of emerging technologies, including wireless sensor networks, cloud computing, big data analytics, artificial intelligence, and blockchain, and their integration within IoT-based agricultural systems. The survey highlights how these technologies enable real-time monitoring, data-driven decision-making, automation of farming processes, and improved resource efficiency. The paper also categorizes IoT applications in areas such as soil monitoring, irrigation management, pest detection, crop health assessment, and livestock tracking. Furthermore, the review discusses key challenges such as data security, scalability, interoperability, and infrastructure limitations, offering future research directions. This comprehensive analysis provides valuable insights into the current state and future potential of IoT in achieving sustainable, efficient, and intelligent agricultural practices [2].

Recent studies such as Ahmed et al. (Smart Agriculture: Current State, Opportunities, and Challenges) provide a comprehensive overview of how digital technologies are transforming modern agriculture. The authors highlight that advancements in IoT sensors, wireless communication, cloud computing, and data analytics have enabled real-time monitoring of soil, crops, and environmental conditions, significantly improving decision-making and resource management. Their review also emphasizes the increasing role of machine learning and artificial intelligence in automating tasks like disease detection, yield prediction, and precision irrigation. Furthermore, the study identifies emerging opportunities such as autonomous robots, blockchain-based traceability, and smart supply-chain systems that can enhance productivity and sustainability. However, the literature also points out persistent challenges, including high deployment costs, limited connectivity in rural regions, data privacy concerns, and the need for technical training among farmers. Overall, the paper synthesizes existing research to show that while smart agriculture holds immense potential, addressing infrastructural and socio-economic barriers is crucial for widespread adoption [3].

At the review stage, the study titled "Economy-wide Impact of Climate Smart Agriculture in India: A SAM Framework" by Ananya Ajatasatru, Vishnu Prabhu, Barun Deb Pal, and Kakali Mukhopadhyay presents a comprehensive assessment of the broader economic implications of adopting climate-smart agriculture (CSA) in India using a Social Accounting Matrix (SAM) framework. The authors review how CSA practices—such as improved irrigation, crop diversification, and sustainable land use—affect not only agricultural productivity but also labor, household income, and overall economic growth. By applying the SAM model, the paper evaluates both direct and indirect linkages between agriculture and other sectors of the economy, offering a macro-level perspective on sustainability. The study highlights that CSA adoption can lead to increased rural employment, better income distribution, and long-term economic resilience. At this review stage, the literature contributes valuable insight into the systemic benefits of CSA, emphasizing its potential to support India's sustainable development goals while addressing the socio-economic challenges posed by climate change [4].

The study by Mujeyi, Mudhara, and Mutenje investigates how the adoption of Climate Smart Agriculture (CSA) practices influences household welfare in smallholder integrated crop–livestock systems in Zimbabwe. The literature indicates that CSA practices—such as conservation agriculture, improved livestock management, drought-tolerant crop varieties, and water-efficient technologies—are increasingly promoted to strengthen resilience against climate variability. Empirical findings from the review highlight that households adopting a combination of CSA practices tend to experience improved food security, higher productivity, and better income stability compared to non-adopters. The study further shows that welfare gains are strongest when farmers implement multiple, complementary CSA practices, suggesting synergy between crop and livestock components. However, the literature also points out that adoption is often hindered by limited access to extension services, credit, inputs, and climate information, which restricts smallholders from fully benefiting from CSA [5].

The study by Chen et al. presents an AIoT-based smart agricultural system designed for real-time pest detection and monitoring. Integrating sensors, IoT connectivity, and AI image-processing models, the system enhances accuracy in identifying pest infestations at early stages. Literature shows that such AIoT solutions help farmers reduce crop losses, optimize pesticide usage, and enable timely interventions. The authors highlight that automated detection significantly improves decision-making compared to traditional manual scouting. Overall, the system demonstrates how combining AI and IoT can strengthen precision agriculture and support sustainable pest-management practices [6].

At the review stage, the study titled "AgriFusion: An Architecture for IoT and Emerging Technologies Based on a Precision Agriculture Survey" by Ritesh Kumar Singh, Rafael Berkvens, and Maarten Weyn presents a comprehensive literature-based framework that integrates IoT with other emerging technologies to enhance precision agriculture. The authors propose the AgriFusion architecture, which is developed after analyzing existing IoT-based agricultural solutions and identifying gaps in scalability, interoperability, and data integration. The review discusses how technologies such as wireless sensor networks, machine learning, UAVs (drones), blockchain, and cloud computing can be combined under a unified architecture to support real-time monitoring, decision-making, and automation in farming [7].

At the review stage, the study titled "Internet of Things (IoT)-Enabled Machine Learning Models for Efficient Monitoring of Smart Agriculture" by Mohammad Aldossary, Hatem A. Alharbi, and Ch Anwar Ul Hassan provides an in-depth literature-based analysis of how IoT and machine learning (ML) can be combined to optimize agricultural monitoring systems. The authors review existing research and frameworks that utilize IoT devices—such as soil sensors, weather stations, and image-capturing tools—to collect real-time data from farms. This data is then processed using machine learning algorithms to predict crop health, detect diseases, manage irrigation, and forecast yields. The study highlights how ML models improve decision-making by analyzing complex agricultural datasets for patterns and anomalies. Furthermore, it explores the benefits of automated systems in reducing labor, conserving resources, and increasing productivity. At the review stage, this paper lays the groundwork for developing intelligent, data-driven agricultural solutions, emphasizing the critical role of IoT-ML integration in advancing smart and sustainable farming practices. [8].

The review by Ghulam Mohyuddin et al. evaluates different machine learning techniques used in precision farming within smart agriculture systems. The authors show that algorithms such as decision trees, SVMs, neural networks, and deep learning models are widely applied for crop prediction, disease detection, yield estimation, and soil analysis. The literature highlights that machine learning improves accuracy and efficiency compared to traditional methods, helping farmers make timely and data-driven decisions. The study also notes challenges such as limited datasets, sensor noise, and the need for high computational resources, which affect real-world deployment. Overall, the review emphasizes that machine learning plays a crucial role in advancing smart agriculture but requires better data quality and system integration for large-scale adoption. [9].

At the review stage, the study titled "Financing Climate-Smart Agriculture: A Case Study from the Indo-Gangetic Plains" by Roberto Villalba, Garima Joshi, Thomas Daum, and Terese E. Venus explores the financial dimensions of adopting climate-smart agriculture (CSA) in one of India's most critical agricultural regions. The authors review existing funding mechanisms, institutional support systems, and barriers that smallholder farmers face in accessing finance for CSA technologies such as precision irrigation, stress-tolerant crop varieties, and conservation practices. Through a detailed case study of the Indo-Gangetic Plains, the paper highlights the importance of tailored financing models, public-private partnerships, and government incentives in scaling CSA adoption. It also examines how credit availability, awareness, and risk perceptions influence farmer behavior [10].

III. PROPOSED SYSTEM

The proposed system for smart farming with sensors and automated pest control is designed to create a responsive, data-driven agricultural environment that enhances productivity and sustainability. At its core, the system integrates a network of sensors—including soil moisture, temperature, humidity, and pest detection modules—strategically placed across the farm to continuously monitor environmental and crop conditions. These sensors transmit real-time data to an IoT gateway, which aggregates and forwards the information to a cloud-based analytics platform. Here, machine learning algorithms analyze the data to detect anomalies, predict pest outbreaks, and recommend targeted interventions. Based on these insights, automated pest control mechanisms such as smart sprayers, pheromone traps, and AI-powered drones are activated to apply treatments precisely where needed, minimizing chemical usage and environmental impact. Farmers interact with the system through a user-friendly dashboard accessible via mobile or web, allowing them to visualize data trends, receive alerts, and manually override or schedule actions. The system also includes security protocols to ensure data privacy and secure communication between devices. Overall, this integrated architecture offers a scalable, efficient, and sustainable solution for modern agriculture, empowering farmers to make informed decisions and respond proactively to pest threats.

Expanding further on the proposed system for smart farming with sensors and automated pest control, the architecture can be enhanced with advanced features that improve scalability, intelligence, and sustainability. One such enhancement is the integration of edge computing, which allows data to be processed locally at the sensor or gateway level rather than relying solely on cloud servers. This reduces latency and enables faster decision-making, especially critical for time-sensitive pest control actions. Additionally, machine learning models can be trained on historical and real-time data to predict pest outbreaks based on environmental patterns, crop growth stages, and previous infestation records. These predictive models can trigger automated responses even before visible signs of damage occur.

The system can also incorporate blockchain technology to ensure secure and transparent data sharing among stakeholders such as farmers, agronomists, and supply chain partners. This builds trust and enables traceability in pest management practices. Furthermore, energy-efficient sensor design and solar-powered automation units can make the system more sustainable and suitable for deployment in remote or resource-constrained areas.

To support farmers, the system should include multilingual voice-enabled interfaces and AI chat assistants that guide users through diagnostics, recommendations, and manual overrides. These interfaces can be tailored to local languages and literacy levels, improving accessibility and adoption. Finally, the system should be modular, allowing farmers to start with basic monitoring and gradually add automation features as needed. This flexibility ensures that the technology can be adapted to diverse agricultural contexts—from smallholder farms to large commercial operations—making smart farming a practical and inclusive solution for global food security.

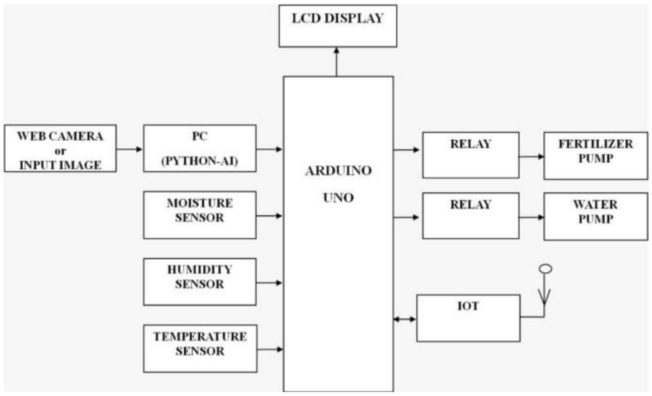

Fig 3.1 Proposed System

The agricultural monitoring and control system depicted in the diagram integrates various technologies to optimize farming operations. It begins with a power supply unit—comprising battery, solar, and SMP5 sources—that energizes a suite of sensors. These include a soil moisture sensor, a temperature and humidity sensor, a camera sensor (BCB/IR) for capturing pest images, and a pheromone trap with an optional scanner sensor. Data collected from these sensors is transmitted via a Wi-Fi or UIoT module to the cloud, enabling real-time connectivity. This information is then accessible through a mobile app or web dashboard, which provides live updates and allows for manual control. Based on sensor inputs, the system can activate two key outputs: a water pump for irrigation and an automated spray mechanism for pest control, thereby enhancing precision agriculture and reducing manual labor.

This smart farming system is powered by a versatile power supply unit, such as a battery, solar panel, or SMPS, which supports continuous operation. The core sensing section includes multiple sensors: a soil moisture sensor to monitor water levels in the soil, a temperature and humidity sensor to track environmental conditions, a camera sensor (RGB or IR) for capturing pest images, and a pheromone trap with an optical sensor or camera to detect pest presence. All sensor data is fed into a microcontroller unit, such as ESP32, Node MCU, or Arduino with ESP8266, which processes the information and controls the system.

The microcontroller communicates with the cloud via a Wi-Fi/IoT module using platforms like Blynk, Firebase, or Thing Speak, enabling real-time data upload and AI-based analysis. Farmers can monitor the farm and manually control operations through a mobile app or web dashboard that provides live updates. Based on sensor data and user input, the system activates relay and actuator controls to operate devices such as a water pump for irrigation or an automated sprayer for pest control, ensuring precise and efficient farm management with minimal human intervention.

Certainly! This smart farming system leverages a comprehensive network of sensors and automation to enhance crop management and pest control. The soil moisture sensor continuously measures the water content in the soil, enabling precise irrigation decisions to prevent under- or over-watering. The temperature and humidity sensor monitors the climatic conditions, crucial for assessing crop health and predicting pest outbreaks. The camera sensor, which can be RGB or infrared, captures detailed images of pests, allowing for early detection and accurate identification. Complementing this, the pheromone trap equipped with an optical sensor or camera detects specific pest species by attracting them and monitoring their presence, enhancing targeted pest management.

All this sensor data is centrally processed by a microcontroller unit like ESP32 or Arduino, which serves as the system's brain. This unit not only gathers and analyzes the data but also manages communication with cloud services through Wi-Fi or IoT modules, using platforms such as Blynk, Firebase, or Thing Speak. These cloud platforms enable advanced AI and machine learning algorithms to further analyze data trends, predict pest infestations, and optimize resource use.

IV. RESULTS AND DISCUSSION

Studies and implementations across various agricultural settings have yielded promising outcomes:
Enhanced Pest Detection Accuracy: Systems using IoT and image processing techniques can detect pests with high precision. For example, camera sensors combined with pheromone traps and image recognition algorithms have achieved detection accuracies above 90% in controlled environments.

Reduced Pesticide Usage: Automated spraying mechanisms triggered by sensor data allow targeted pest control, reducing pesticide application by up to 40% compared to traditional methods.

Improved Crop Yield: Real-time monitoring of soil moisture, temperature, and humidity ensures optimal growing conditions. Farms using these systems have reported yield increases of 15–25% due to better resource management.

Labor Efficiency: Automation of irrigation and pest control reduces the need for manual intervention, saving time and labor costs. Farmers can monitor and control operations remotely via mobile apps or dashboards.

Smart farming systems represent a paradigm shift from reactive to proactive agricultural practices. By integrating sensors (e.g., soil moisture, temperature, pest detection) with cloud-connected control units, farmers gain actionable insights and can automate responses like irrigation and spraying.

Key advantages include:
Precision Agriculture: Data-driven decisions minimize waste and maximize productivity.

Sustainability: Reduced chemical usage and optimized water consumption contribute to environmental conservation.

Scalability: These systems can be adapted for small farms or large-scale operations with modular components.

Challenges remain, such as the initial cost of deployment, need for technical training, and ensuring reliable connectivity in rural areas. However, ongoing research and government support are helping to overcome these barriers.

V. CONCLUSION

Smart farming systems that integrate sensor technologies and automated pest control represent a transformative leap in agricultural practices. By enabling real-time monitoring of environmental conditions and pest activity, these systems empower farmers to make data-driven decisions that enhance crop health, optimize resource use, and reduce dependency on manual labor and chemical inputs. The synergy between IoT-based sensors, cloud connectivity, and automated responses—such as targeted irrigation and precision spraying—leads to increased efficiency, sustainability, and profitability. As these technologies become more accessible and scalable, they hold the potential to revolutionize agriculture, making it smarter, more resilient, and better equipped to meet the demands of a growing global population.

REFERENCES

1. ching -Ju Chen, Yayu Huang, yuan-Shuo li, chanoyu chang and Yueh-min Huang, An IoT Based Smart Agricultural System for Pests Detection IEEE (2020)
2. Ritesh Kumar Singh , Rafael Berkven's, and Maarten weyn.,, An Architecture for IOT and Emerging
3. Technologies Based on a Precision Agriculture Survey IEEE (2021)
4. Mohammad Aldossary, Hatem A. Alharbi, And Ch-Anwar Ul Hassan, Internet of Things (IoT)-Enabled Machine Learning Models for Efficient Monitoring of Smart Agriculture IEEE (2024)
5. Ghulam Mohiuddin, Muhammad Adnan khan , Abdul Haseeb, Shahzadi , Muhammad Waseem, and Ahmed Mohammed Saleh,, Evaluation of Machine Learning Approaches for Precision Farming in Smart Agriculture IEEE (2024)

6. Ananya Ajatasatru, Vishnu Prabhu, Barun Deb Pal and Kakali Mukhopadhyay, Economy wide impact of climate smart agriculture in India Springer (2024)
7. Wanglin Ma, Dil Bahadur Rahut , Climate Smart Agriculture:Adaption,Impacts for sustainable development Springers (2024)
8. Bilal Ahmed, Hasnat Shabbir , Syed Rameez Naqvi , and lu peng, Smart Agriculture: Current State, Opportunities, and Challenges IEEE (2024)
9. Othmane Friha, Mohamed Amine Ferrag, Lei Shu, Leandros Maglaras, and Xiaochan Wang.,Internet of Things for the Future of Smart Agriculture, IEEE (2021)
10. Angeline Mujeyi , Maxwell Mudhara1 and Munyaradzi Mutenje Climate smart agriculture on household welfare in small holder integrated crop–livestock farming systems Springer (2021).
11. Roberto Villalba,Garima Joshi, Thomas Daum, Terese E. Ven. Financing Climate-Smart Agriculture a case study from the Indo-Gangetic Plains Springer (2024)