Transforming Agriculture with IoT and AI: A Comprehensive Crop Monitoring and Management System

B. Marikumar, M. Arjun, A. Arul Thiraviam, K. Gowtham Sidharth, G. Vasunthraa and S. Roshini

Department of Computer Science and Engineering, V.S.B College of Engineering Technical Campus, Kinathukadavu, Coimbatore, Tamil Nadu, India

Keywords: Blockchain Technology, Smart Technology Integration, Real-Time Decision Making, Machine Learning Algorithms, Edge Computing Analyses, Soil Moisture, Temperature, Humidity, Light Intensity.

Abstract: Agriculture remains crucial for food production; however, it is continuously impacted by climate change, limited water supply, pest infestation, and poor management of resources. Farming practices of the past are no longer sufficient, requiring new approaches. In this paper, I present and, in this paper, I discuss the development and deployment of an intelligent Internet of Things (IoT)-based agricultural crop monitoring and control system that automates farming through smart technology integration. Smart sensors form a network for monitoring environmental factors including soil moisture, temperature, humidity, light intensity, and soil ph. Drones offer fully automated aerial imaging for remote sensing to monitor crop health, while edge computing analyses data close to the source for real-time decision making. The cloud serves as the system's repository and the machine learning algorithms provide predictive analysis, which enables farmers to take proactive measures against pest infestation and bad weather. Furthermore, blockchain technology guarantees security, transparency, and traceability of products in an agricultural supply chain. Farmers can access real-time concrete guidance through the mobile app or the web app, enabling them to make informed decisions such as conserving water, fertilizers, and pesticides.

1 INTRODUCTION

The agricultural sector remains crucial to world food security but struggles with climate change, water and pest management, and poor resource mobilization. Efforts toward modern service industrialization have made traditional farming, which depends on manual labour and simple agricultural tools, unfit to meet contemporary requirements. This project seeks to solve these problems by implementing sophisticated technologies so that they can assist farmers in overcoming challenges by developing an advanced IoT-based crop monitoring system. The system is designed to optimize agrotechnology's, improve productivity, and foster sustainable agricultural practices. The integration of IoT, edge computing, drone technology, machine learning, and blockchain delivers a holistic approach to farmers of all scales, allowing for data-driven approaches to move farming away from guesswork towards enhanced production and lowered repercussions on the ecosystem.

1.1 System Overview

The modules included in the system are as follows:

- Smart Sensor Network: Keeps track of environmental factors like soil moisture, temperature, humidity, light intensity, and soil PH.
- Edge Computing Unit: Analyses information on site to decrease latency and improve responsiveness.
- Drone Surveillance: Takes overhead pictures of the fields to check the health of the crops and identify pest issues.
- Cloud Based Platform: Uses the data and applies machine learning for data analysis and information storage as well as predictive analytics.
- Blockchain Framework: Guarantees the traceability and transparency of the agricultural supply chain data.

Marikumar, B., Arjun, M., Thiraviam, A. A., Sidharth, K. G., Vasunthraa, G. and Roshini, S.
Transforming Agriculture with IoT and AI: A Comprehensive Crop Monitoring and Management System.
DOI: 10.5220/0013925800004919

In *Proceedings of the 1st International Conference on Research and Development in Information, Communication, and Computing Technologies (ICRDICCT'25 2025) - Volume 5*, pages 238-242
ISBN: 978-989-758-777-1

- Controlled Systems: Controls the sensors and actuators for irrigation, fertilization, and pest control in conjunction with real-time data.
- Community Knowledge-Sharing Platform: Promotes interaction and creativity among farmers.

1.2 Before IoT System

1.2.1 Smart Sensor Network

A network of smart sensors is deployed over agricultural fields to monitor vital environmental parameters. These sensors report text messages for soil moisture content, temperature, humidity, light intensity, and soil ph in real time. The data is processed locally with edge computations to ensure timely responses to critical changes, such as sudden drops in soil moisture or temperature spikes.

1.3 Edge Computing Unit

The edge unit does local data processing to eliminate response latency. This ensures prompt protective interventions to maintain crop health. The processed information is relayed to a central microcontroller which fuses the data and uploads it to a cloud platform for detailed processing. Figure 1 shows the Representation of before IoT Invention in Agriculture field. Figure 2 shows the Representation of after IoT Invention in Agriculture field.

Figure 1: Representation of before IoT Invention in Agriculture field.

1.3.1 After IoT System

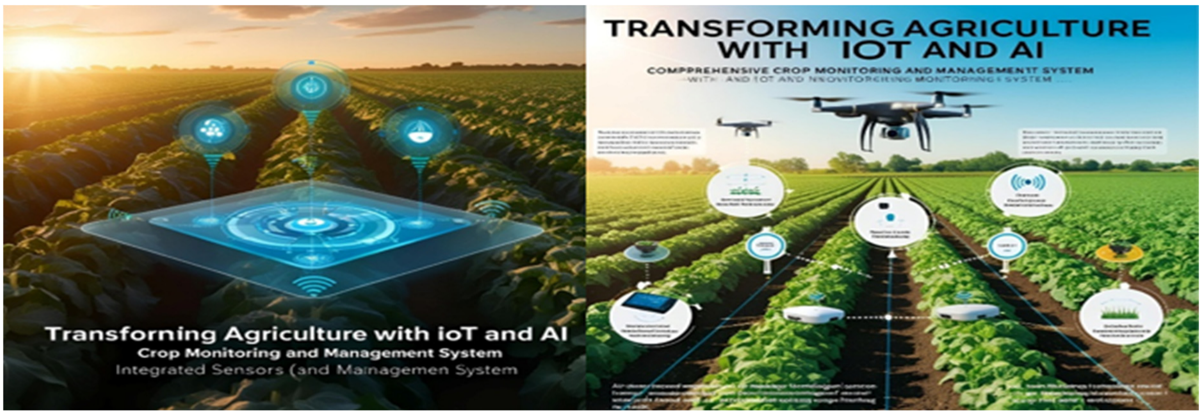

Figure 2: Representation of after IoT Invention in Agriculture field.

1.4 Drone Surveillance

Farms are surveyed using drones that have high resolution cameras and multispectral sensors to take pictures of the fields. This sensor provides high aerial data and when combined with ground data captures, help the farmers acquire better understanding of their fields and more articulation in the necessary adjustments.

1.5 Cloud-Based Platform

This cloud platform is the systems brain where data is stored and visualized using sophisticated mobile and web applications interfaces. Advanced machine learning analyses the information to create predictive analytics of greatly potential problems such us pest infestation, disease outbreak or we

1.6 Blockchain Structure

The data management framework utilizes blockchain technology to maintain an unalterable record of agricultural activities. This improves accountability and traceability in the supply chain while satisfying regulatory needs and consumer expectations.

1.7 Self-Regulating Control Mechanisms

Real-time sensor data triggers automated irrigation, fertilization, and pest control systems. For instance, if soil moisture is recorded below a specific value, crops are watered as the system initiates irrigation.

1.8 Farmers' Innovative Practices Community Platform

The platform features a community-based innovative practices sharing platform where farmers share knowledge, strategies, and solutions relevant to local constraints. This improves collaborative innovation as farmers support each other and respond to variability more effectively.

2 A SYSTEM DEVELOPMENT AND DEPLOYMENT

2.1 Intelligent Sensor System

- Parts: pH, light, temperature, humidity, and soil moisture sensors.
- Operation: Captures information on environmental conditions and sends it to the edge computing unit for further processing.

2.2 Edge Computing Unit

- Parts: Edge computing module, microcontroller.
- Operation: Controls the captured data locally to decrease latency and enable quicker responses.

2.3 Drone Surveillance

- Componentry: Drones with high resolution cameras and multispectral sensors.
- Operational: Takes aerial photographs to assess plant health and identify potential pests.

2.4 Cloud Based Platform

- Componentry: Cloud server, machine learning, mobile and web applications.
- Operational: Data storage and analysis, predictive modelling, and insight generation to farmers.

2.5 Blockchain Framework

- Componentry: Blockchain network and QR codes.
- Operational: Principally guarantees visibility and traceability within the agriculture supply chain.

2.6 Automated Control Systems

- Componentry: Automated irrigation, fertilization, and pest control systems.
- Operational: Carried out automated processes dependent on real-time sensor information.

2.7 Community Knowledge Sharing Platform

- Componentry: Online platform, professional consultation, published research papers, training documentation.
- Operational: Enable farmers to collaborate and enhance productivity through innovation.

3 LITERATURE REVIEW

3.1 Current Systems and Their Challenges

- Excessively Expensive: Sensors, drones, and other hardware IoT-based systems come with high costs that are typically out of reach for small-scale farmers.
- Rural areas have unreliable internet coverage which obstructs real-time data streaming and analytics.
- Farmers who do not have sufficient training and experience using IoT systems have a tough time trying to understand and interpret the hundreds of data points IoT-enabled systems generate.
- Remote and off-grid farming areas are prone to unreliable power sources which poses a problem for many IoT devices that need constant power.
- Smart sensors and drones have to undergo routine maintenance and recalibrations that many farmers find difficult to perform due to the level of skill required.
- The current smart systems available are not designed to accommodate businesses of different sizes, making it more difficult for larger operations to scale.
- IoT systems are open to cyberattack without strong encryption, risking data security and privacy.
- The lack of sufficient historical data and localized variable consideration results in reduced predicted accuracy from machine learning models.
- Different manufacturers' devices and platforms are often incompatible with each other, leading to less efficient work processes.

4 RESEARCH DESIGN

4.1 System Architecture

The system is made up of these parts:

- **Smart Sensor Network:** It gathers real-time info about things like soil, weather, and crops.
- **Edge Computing Unit:** It processes data right where it's collected to make things faster.
- **Drone Surveillance:** Drones take pictures from the air to check how healthy the crops are.
- **Cloud-Based Platform:** It stores all the data and uses smart tools to analyse it.
- **Blockchain Framework:** It keeps everything clear and traceable, so you can track where stuff comes from.
- **Automated Control Systems:** It handles watering, adding fertilizers, and dealing with pests automatically.
- **Community Knowledge-Sharing Platform:** A place where farmers can share tips, ideas, and work together to improve farming. Figure 3 illustrates the Impact of IoT on Farming Efficiency over Time.

5 RESULTS AND DISCUSSION

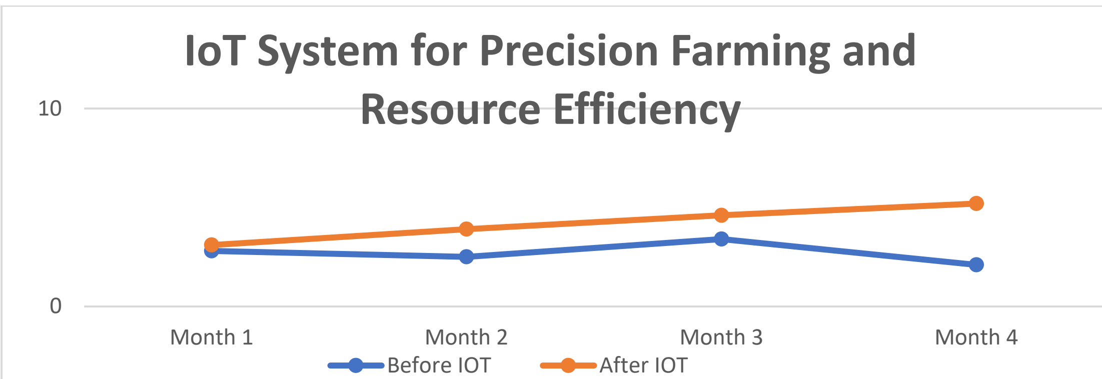

Figure 3: Impact of IoT on Farming Efficiency over Time.

6 CONCLUSIONS

This IoT crop monitoring system is a huge step forward for smart farming. It uses high-tech tools to give farmers real-time updates, smart guesses about what’s coming, and automatic controls to help them use water, fertilizer, and other stuff more efficiently and grow more crops. It’s easy to use, works for small or big farms, and is good for both the planet and the wallet. This system is a great way to solve today’s farming problems and create a future where food is more sustainable and reliable.

REFERENCES

Christodoulou, A., Christidis, P., and Bissel ink, B., 2020. Forecasting the impacts of climate change on inland waterways. Transportation Research Part D: *Transport and Environment,* 82: 102159.

Weng, C.N., 2005. Sustainable management of rivers in Malaysia: Involving all stakeholders. *International Journal of River Basin Management*, 3(3): 147-162.

Tori man, M.E., Hassan, A.J., Gazim, M.B., Mokhtar, M., SA, S.M., Jaafar, O., and Aziz, N.A.A., 2009. *Integration* of 1-d hydrodynamic model and GIS approach in flood management study in Malaysia. *Research Journal of Earth Sciences*, 1(1): 22-27.

Kamarudin, M.K.A., Tori man, M.E., Wahab, N.A., Rosli, H., Ata, F.M., and Faudzi, M.N.M., 2017. Sedimentation study on upstream reach of selected rivers in Pahang River Basin, Malaysia. *International Journal on Advanced Science, Engineering and Information Technology,* 7(1): 35-41.

Adhiharto, R., and Komara, F.A., 2018. Perancangan Konstruksi Trash Bucket Conveyor (Tbc) Sebagai Mekanisme Pembersih Sampah Di Sungai.

Khekare, G.S., Dhanre, U.T., Dhanre, G.T., and Yede, S.S., 2019. Design of Optimized and Innovative Remotely Operated Machine for Water Surface Garbage Assortment. *International Journal of Computer Sciences and Engineering*, 7(1): 113-117.

Othman, H., Petra, M.I., De Silva, L.C., and Caesarendra, W., 2020. Automated trash collector design. In *Journal of Physics: Conference Series*, 1444(1): 012040.

Kader, A.S.A., Saleh, M.K.M., Jalal, M.R., Sulaiman, O.O., and Shamsuri, W.N.W., 2015. Design of rubbish collecting system for inland waterways. *Journal of Transport System Engineering,* 2(2): 1-13.

Akib, A., Tasnim, F., Biswas, D., Hashem, M.B., Rahman, K., Bhattacharjee, A., and Fattah, S. A., 2019. Unmanned Floating Waste Collecting Robot. In *TENCON 2019-2019 IEEE Region 10 Conference (TENCON),* 2645-2650.

Balasuthagar, C., Shanmugam, D., and Vigneshwaran, K., 2020. Design and fabrication of beach cleaning machine. *In IOP Conference Series: Materials Science and Engineering*, 912(2): 022048.

Kong, S., Tian, M., Qiu, C., Wu, Z., and Yu, J., 2020. IWSCR: An intelligent water surface cleaner robot for collecting floating garbage. *IEEE Transactions on Systems, Man, and Cybernetics: Systems,* 1-11.

Lindquist, A., 2016. Baltimore’s Mr. Trash Wheel. The *Journal of Ocean Technology,* 11(12): 35-37.

Geraeds, M., van Emmerik, T., de Vries, R., and bin Ab Razak, M.S., 2019. Riverine plastic litter monitoring using unmanned aerial vehicles (UAVs). *Remote Sensing*, 11(17): 2045.