International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 11 Issue: 02 | Feb 2024 www.irjet.net p-ISSN: 2395-0072

"A Paradigm Shift in Agriculture: Integrating IoT and Blockchain for Automated Harvesting System"

Kunchapu Devakumar[1], Degala Saranya[2], Degala Jwalitha[3], Indla Sneha Latha[4]

[1]*UG student Dept of IOT , VVIT, Andhra Pradesh, India*
[2]*UG student Dept of Cyber security, IOT incl. Blockchain Technology , VVIT, Andhra Pradesh, India*
[34]*UG student Dept of Artificial Intelligence and Machine Learning , GECG , Andhra Pradesh, India*

Abstract - *This research paper explores the intricate amalgamation of cutting-edge technologies, namely the Internet of Things (IoT) and Blockchain, to propel a paradigm shift in automated harvesting systems within the agricultural domain. The imperative for heightened operational efficiency, transparency, and traceability in food production necessitates innovative solutions capable of addressing pivotal challenges such as data security, reliability, and real-time monitoring. This trove of data forms the bedrock for judicious decision-making and predictive analytics, ultimately optimizing the entirety of the harvesting process. Nevertheless, the reliance on centralized data storage systems raises significant apprehensions regarding data integrity, security, and trust. Blockchain technology, renowned for its decentralized and immutable ledger, emerges as a potent solution to assuage these concerns. The integration of smart contracts onto a blockchain automates and fortifies transactions within the harvesting ecosystem, guaranteeing data integrity and establishing an unassailable, transparent record of the complete harvesting lifecycle. Each network node maintains a synchronized copy of the blockchain, fostering trust among stakeholders and thwarting unauthorized access. The collaborative interplay between IoT and Blockchain in automated harvesting systems holds the promise of augmenting supply chain visibility, mitigating fraud, and fostering a more resilient and sustainable agricultural landscape. This paper meticulously examines diverse use cases, encompassing real-time crop monitoring, predictive maintenance, and transparent supply chain management, offering tangible illustrations of the transformative impact of this integrated methodology.*

***Key Words*: IoT, Blockchain, Automated Harvesting System, Smart Contract, ESP32, Wireless Communication Protocols (Bluetooth, Zigbee, wi-fi, Simcom and BLE), DHT11, Moisture Sensor, PH sensor.**

1.INTRODUCTION

In response to the escalating challenges facing the agricultural sector, there is a growing imperative to adopt innovative technologies that enhance productivity, efficiency, and sustainability. At the forefront of this technological evolution is the integration of Internet of Things (IoT) and blockchain, presenting a transformative synergy poised to reshape agricultural practices. This research paper delves into the confluence of these technologies within the context of an automated harvesting system, elucidating their potential to usher in a new era of intelligent and secure farming. The Internet of Things (IoT) plays a central role in this paradigm shift by seamlessly connecting physical devices, such as sensors and actuators, with digital systems to facilitate real-time data exchange. In the realm of agriculture, this integration is particularly impactful in automated harvesting, where IoT-enabled machinery offers precision farming through data-driven insights. Sensors on harvesting equipment monitor critical parameters such as soil health, crop maturity, and weather conditions, empowering farmers to make informed decisions and optimize the harvesting process. Complementing IoT, blockchain technology provides a decentralized and transparent ledger for recording and validating transactions. Within agriculture, blockchain ensures the creation of an immutable record of the entire supply chain, from seed to harvest to distribution. This fosters traceability and accountability, mitigating risks associated with fraud, contamination, and unethical practices. Through smart contracts, farmers can establish transparent and automated agreements, streamlining processes and reducing dependence on intermediaries. This research paper scrutinizes the technical intricacies of integrating IoT and blockchain technologies into automated harvesting systems, emphasizing their transformative impact on agricultural practices. As the agricultural landscape navigates the complexities of the modern era, the fusion of IoT and blockchain emerges as a beacon of innovation, promising heightened efficiency, transparency, and sustainability in the critical domain of food production.

1.1 Traditional Harvesting System

Traditional harvesting systems have been foundational to agriculture for centuries, adapting to diverse crops, climates, and geographical conditions. The methodical procedure involves a series of manual or semi-manual steps, primarily reliant on human labor and rudimentary tools. Initially, farmers assess the crop's readiness for harvesting by considering parameters such as color, size, texture, and maturity. Subsequently, appropriate manual tools, such as sickles, scythes, or knives, are selected based

on the crop type. The actual harvesting process involves skilled labor manually cutting or gathering mature crops. Post-harvest, crops are often bundled or arranged into bunches for streamlined transportation to storage areas, using traditional carts or animal-drawn methods. Threshing, if applicable, may occur at this stage to separate grains from the plant material. Some crops may undergo drying to reduce moisture content, crucial for preventing mold and ensuring product quality. Following harvesting and optional processing steps, crops are stored in traditional structures like barns or silos to protect them from pests and environmental elements. Depending on the farmer's objectives, crops are either taken to local markets for sale or used for household consumption. While traditional methods have historical significance, challenges related to efficiency and scalability have driven the adoption of modern, technology-driven approaches in contemporary agriculture, aiming to enhance productivity and sustainability.

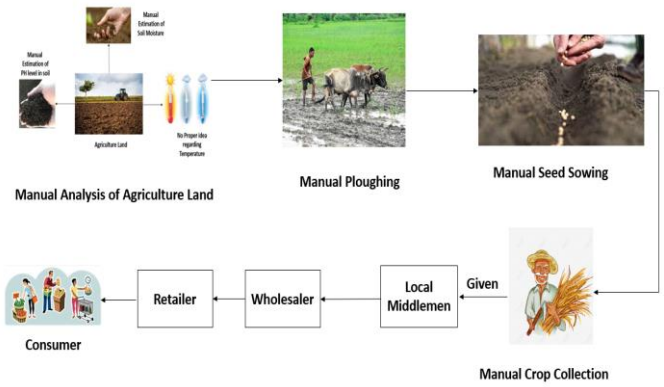

Fig -1: Traditional Harvesting System

1.2 Existed Automated Harvesting System

The IoT-based harvesting system stands as a cutting-edge paradigm in agriculture, integrating a network of sensors, actuators, and communication devices to revolutionize the harvesting process. Deployed sensors, including those for soil moisture, temperature, and crop maturity, continuously collect data transmitted to a central hub for analysis. Employing advanced analytics and machine learning, the system predicts optimal harvesting times based on real-time information and historical data. Autonomous harvesting equipment, equipped with IoT technology, adjusts parameters such as cutting height and speed in response to analyzed data. Robust communication networks enable seamless connectivity, while remote monitoring allows farmers to oversee and intervene as needed. The system's data-driven approach enhances efficiency, resource optimization, and sustainability, marking a significant stride towards precision agriculture in the contemporary landscape.

Fig -2: Existed Automated Harvesting System

2. Proposed System for Automated Harvesting System using IoT and Blockchain Technology

The Automated Harvesting System presented in this research marks a pioneering advancement at the intersection of Internet of Things (IoT) and blockchain technologies, promising a paradigm shift in modern agriculture. Distinguished by a sophisticated suite of sensors, including the DHT11 for environmental monitoring, pH sensors for soil acidity assessment, and moisture sensors for precise irrigation management, this system provides a comprehensive real-time monitoring framework. These sensors collectively deliver nuanced data essential for informed decision-making in the harvesting process, offering farmers unparalleled insights into their agricultural ecosystem. Facilitating seamless communication, the system employs a diverse range of protocols such as Bluetooth, Bluetooth Low Energy (BLE), Wi-Fi, and Simcom. This strategic selection ensures versatile and robust connectivity, enabling efficient data exchange between the harvesting equipment and a centralized hub. The inclusion of Simcom as a communication protocol is particularly noteworthy, as it extends connectivity to remote and challenging terrains, thereby enhancing the system's adaptability and reach. Incorporating blockchain technology into the architecture fortifies the system's data security and transparency across the agricultural supply chain. Immutable records of environmental conditions, harvesting parameters, and crop data are securely stored on the blockchain, fostering a foundation for traceability and accountability. This not only ensures the integrity of the data but also establishes a trustworthy and transparent record of the entire agricultural process. This sophisticated integration of cutting-edge sensors, adept communication protocols, IoT functionalities, and blockchain resilience collectively positions the Automated Harvesting System as an intelligent and transformative force in agriculture. Its intrinsic capabilities in optimizing resource utilization, minimizing waste, and establishing a framework of trust and transparency underscore its significance in revolutionizing contemporary agricultural practices,

paving the way for sustainable and efficient farming in the digital age.

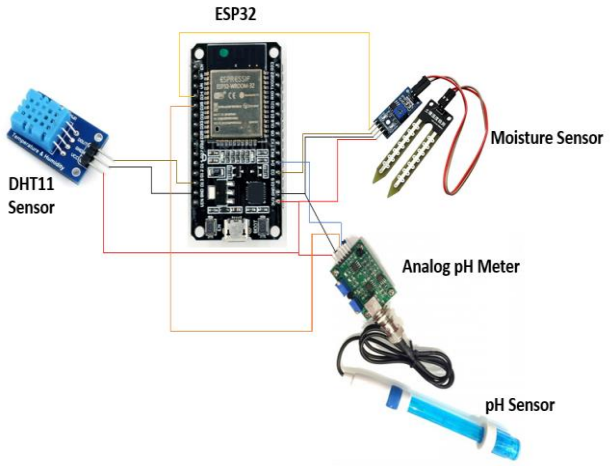

Fig -3: Sensor Connectivity of Automated Harvesting System Using IoT and Blockchain Technology

In the presented configuration, the ESP32 interfaces seamlessly with various sensors, including the DHT11 for precise measurement of environmental temperature and humidity. The incorporation of a pH sensor facilitates the accurate assessment of soil pH levels, vital for cultivating crops in optimal conditions. Additionally, a Moisture sensor is integrated to gauge the soil's moisture percentage, providing essential insights for effective irrigation management. This interconnected sensor array exemplifies a comprehensive approach to environmental monitoring, empowering the Automated Harvesting System with real-time data critical for informed and responsive agricultural decision-making.

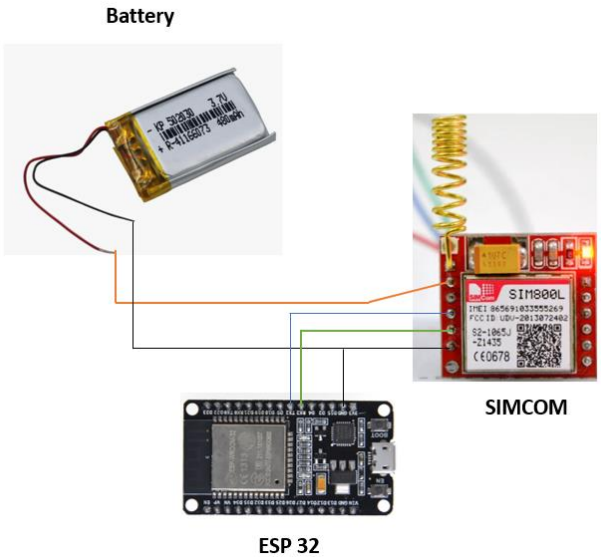

Fig -4: ESP 32 connectivity with SIMCOM for Automated Harvesting System using IoT and Blockchain Technology

The depicted schematic features Simcom's wireless communication technology interfaced with an ESP32 and a LI-PO battery. The transmitter pin (TX2) of the ESP32 is intricately linked to the RX pin of Simcom, establishing a seamless communication pathway. Simultaneously, the receiver pin (RX2) of the ESP32 interfaces with the TX pin of Simcom, ensuring bidirectional data exchange. Ground connections are solidified by linking Simcom's GND with the ESP32's GND. The power supply infrastructure involves connecting the LI-PO battery's positive terminal to Simcom's Vcc and the negative terminal to the ESP32's GND, ensuring a synchronized and robust power distribution.

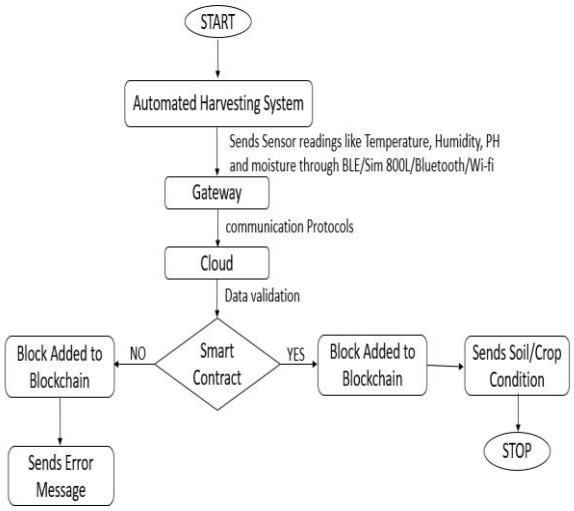

Fig -5: Flow of an Automated Harvesting System Using IoT and Blockchain Technology

3. Automated Harvesting System using IOT and Blockchain- Benefits

1. Precision Agriculture:

- Real-time data from IoT sensors enables precision farming, allowing farmers to make informed decisions based on accurate information regarding soil conditions, crop maturity, and environmental parameters.

2. Resource Optimization:

- Efficient use of resources such as water, fertilizers, and energy is achieved through data-driven insights. This not only reduces waste but also contributes to sustainable and eco-friendly farming practices.

3. Increased Efficiency:

- Automation of the harvesting process improves overall operational efficiency,

reducing the reliance on manual labor and minimizing human errors. This leads to increased productivity and cost-effectiveness.

4. Traceability and Transparency:

- The integration of blockchain ensures an immutable and transparent record of the entire supply chain, from seed to harvest to distribution. This fosters traceability, accountability, and trust among stakeholders.

5. Data-Driven Decision Making:

- Comprehensive data collected by IoT sensors facilitates data-driven decision-making. Farmers can analyze trends, predict optimal harvesting times, and adjust cultivation practices for improved yields.

6. Smart Contracts for Agreements:

- Blockchain's smart contract capabilities enable transparent and automated agreements between farmers and stakeholders, streamlining transactions and reducing the need for intermediaries.

7. Risk Mitigation:

- The real-time monitoring provided by IoT sensors allows farmers to identify potential risks such as pest infestations or adverse weather conditions early on. This proactive approach helps in mitigating risks and minimizing crop losses.

8. Enhanced Quality Control:

- Continuous monitoring of environmental conditions and harvesting parameters ensures the production of high-quality crops. This is particularly crucial in industries where crop quality directly impacts market value.

9. Remote Monitoring and Control:

- Farmers can remotely monitor and control the Automated Harvesting System through IoT-enabled devices. This provides flexibility and allows for timely interventions if necessary.

10. Environmental Sustainability:

- By optimizing resource usage and minimizing waste, the system contributes to environmentally sustainable agricultural practices, aligning with global efforts to reduce the ecological footprint of farming.

4. CONCLUSION

In conclusion, the Automated Harvesting System integrating IoT and blockchain technologies represents a groundbreaking leap forward in the agricultural landscape. This symbiotic fusion of innovation offers a holistic solution to the challenges facing conventional harvesting practices, ushering in a new era of efficiency, sustainability, and transparency. The integration of IoT sensors in the harvesting process brings about a paradigm shift by providing real-time data on critical parameters such as soil conditions, crop maturity, and environmental factors. This precision agriculture approach enables farmers to make informed decisions, optimizing resource utilization and minimizing environmental impact. The system's ability to automate harvesting operations enhances overall efficiency, reducing the reliance on manual labor and mitigating the risk of human error. Furthermore, the incorporation of blockchain technology instills a robust layer of security and transparency throughout the agricultural supply chain. The immutable and decentralized ledger ensures traceability from seed to market, fostering trust among stakeholders and mitigating risks associated with fraud and unethical practices. The use of smart contracts facilitates transparent and automated agreements, streamlining transactions and reducing the need for intermediaries. One of the system's standout features is its contribution to resource optimization. By leveraging real-time data, farmers can precisely tailor their agricultural practices, ensuring optimal use of water, fertilizers, and energy. This not only enhances the economic viability of farming operations but also aligns with global initiatives for sustainable and responsible agriculture. The benefits of the Automated Harvesting System extend beyond the farm gate. The system's remote monitoring capabilities empower farmers to oversee operations from anywhere, providing flexibility and timely intervention in response to changing conditions. This level of control contributes to resilience in the face of uncertainties, be it adverse weather events or pest outbreaks. As we look to the future of agriculture, the integration of IoT and blockchain technologies in the Automated Harvesting System stands as a beacon of innovation. It exemplifies a transformative approach that goes beyond mere mechanization, offering a comprehensive solution that addresses the intricacies of modern farming. While challenges in implementation and adoption may exist, the potential benefits in terms of increased efficiency, sustainable practices, and heightened transparency underscore the significance of this technological evolution in shaping the future of agriculture. The Automated Harvesting System not only marks a technological milestone but also represents a pivotal step towards ensuring food security, economic

viability, and environmental sustainability in the agricultural sector.

REFERENCES

[1] M. Eberhardt and D. Vollrath, "The Effect of Agricultural Technology on the Speed of Development," World Development, vol. 109, pp. 483-496, 2018.

[2] A. Fathallah, "Musculoskeletal disorders in labor-intensive agriculture," Applied Ergonomics, vol. 41, no. 6, pp. 738-743, 2010.

[3] A. R. Proto and G. Zimbalatti, "Risk assessment of repetitive movements in the citrus fruit industry," Journal of Agricultural Safety and Health, vol. 16, no. 4, pp. 219-228, 2010.

[4] Z. Zhang, Y. Wang, Z. Zhang, D. Li, Z. Wu, R. Bai and G. Meng, "Ergonomic and efficiency analysis of conventional apple harvest process," International Journal of Agircultural and Biological Engineering, vol. 12, no. 2, p. 210–217, 2019b.

[5] Z. Zhang, Z. Zhang, X. Wang, H. Liu, Y. Wang and W. Wang, "Models for economic evaluation of multi-purpose apple harvest platform and software development," International Journal of Agricultural and Biological Engineering, vol. 12, no. 1, pp. 74-83, 2019c.

[6] V. Marinoudi, C. G. Sørensen, S. Pearson and D. Bochtis, "Robotics and labour in agriculture. A context consideration," Biosystems Engineering, vol. 184, pp. 111-121, 2019.

[7] S. Fountas, N. Mylonas, I. Malounas, E. Rodias, C. H. Santos and E. Pekkeriet, "Agricultural Robotics for Field Operations," Sensors, vol. 20, no. 9, p. 2672, 2020.

[8] R. R. Shamshiri, C. Weltzien, I. A. Hameed, I. J. Yule, T. E. Grift, S. K. Balasundram, L. Pitonakova, D. Ahmad and G. Chowdhary, "Research and development in agricultural robotics: A perspective of digital farming," International Journal of Agricultural and Biological Engineering, vol. 11, no. 4, pp. 1-11, 2018.

[9] C. W. Bac, E. J. v. Henten, J. Hemming and Y. Edan, "Harvesting Robots for High-value Crops: State-of-the-art Review and Challenges Ahead," Journal of Field Robotics, vol. 31, no. 6, pp. 888-911, 2014. 22

[10] D. C. Slaughter, D. K. Giles and D. Downey, "Autonomous robotic weed control systems: A review," Computers and Electronics in Agriculture, vol. 61, no. 1, pp. 63-78, 2008.

[11] Q. Zhang, M. Karkee and A. Tabb, "The use of agricultural robots in orchard management," Burleigh Dodds Series in Agricultural Science, pp. 187-214, 2019a.

[12] A. Bechar and C. Vigneault, "Agricultural robots for field operations. Part 2: Operations and systems," Biosystems Engineering, vol. 153, p. 110–128, 2017.

[13] V. Saiz-Rubio and F. Rovira-Más, "From Smart Farming towards Agriculture 5.0: A Review on Crop Data Management," Agronomy, vol. 10, no. 2, p. 207, 2020.

[14] C. P. Baillie, J. A. Thomasson, C. R. Lobsey, C. L. McCarthy and D. L. Antille, "A review of the state of the art in agricultural automation. Part I: Sensing technologies for optimization of machine operation and farm inputs," in ASABE Annual International Meeting, St. Joseph, Michigan, 2018.

[15] K. G. Fue, W. M. Porter, E. M. Barnes and G. C. Rains, "An Extensive Review of Mobile Agricultural Robotics for Field Operations: Focus on Cotton Harvesting," AgriEngineering, vol. 2, no. 1, p. 150–174, 2020.

[16] S. G. Defterli, Y. -. Shi, Y. -. Xu and R. -. Ehsani, "Review of Robotic Technology for Strawberry Production," Applied Engineering in Agriculture, vol. 32, no. 3, p. 301–318, 2016.

[17] K. R. Aravind, P. Raja and M. Pérez-Ruiz, "Task-based agricultural mobile robots in arable farming: A review," Spanish Journal of Agricultural Reseasrch, vol. 15, no. 1, p. 16, 2017.

[18] N. Tsolakis, D. Bechtsis and D. Bochtis, "Agros: A robot operating system based emulation tool for agricultural robotics," Agronomy, vol. 9, no. 7, p. 403, 2019.

[19] P. Li, S.-h. Lee and H.-Y. Hsu, "Review on fruit harvesting method for potential use of automatic fruit harvesting systems," Procedia Engineering, vol. 23, p. 351–366, 2011.

[20] G. E. Coppock and S. L. Hedden, "Design and Development of a Tree-Shaker Harvest System for Citrus Fruit," Transactions of the ASAE, vol. 11, no. 3, p. 339–342, 1968.

[21] H. R. Sumner, S. L. Hedden and L. Alfred, "Harvesting oranges with a full-powered positiong limb shaker," Floriad State Horticultural Society, p. 117–120, 1975.

[22] A. Torregrosa, E. Ortí, B. Martín, J. Gil and C. Ortiz, "Mechanical harvesting of oranges and mandarins in Spain," Biosystems Engineering, vol. 104, no. 1, pp. 18-24, 2009. A. Silwal, J. R. Davidson, M. Karkee, C. Mo, Q. Z

[23] hang and K. Lewis, "Design, integration, and field evaluation of a robotic apple harvester," Journal of Field Robotics, vol. 34, no. 6, pp. 1140-1159, 2017. 23

[24] J. Baeten, K. Donné, S. Boedrij, W. Beckers and E. Claesen, "Autonomous Fruit Picking Machine: A Robotic Apple Harvester," Field and Service Robotics, vol. 42, p. 531–539, 2008.

[25] D. M. Bulanon and T. Kataoka, "A Fruit Detection System and an End Effector for Robotic Harvesting of Fuji Apples," Agricultural Engineering International: CIGR Journal, vol. 12, pp. 203-210, 2010.

Author Details

1. Kunchapu Devakumar
Student
VVIT

2. Degala Saranya
Student
VVIT

3. Degala Jwalitha
Student
GECG

4. Indla Sneha Latha
Student
GECG