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OSIKANI Farm Solution: Optimized Solar-Integrated Knowledgeable Agricultural Node for Innovation
A Low-Cost, Remote-Controlled Smart Farming System for Sustainable Small-scale Farming

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Abstract

This work presents the OSIKANI Farm Solution, developed to address persistent challenges in small-scale farming such as labor shortages, unreliable power supply, and inefficient use of resources. The system was built from locally sourced materials and incorporated a 60 W solar panel, rechargeable lithium battery, high torque DC motors, sensors, relays, and a GSM module for mobile alerts. A dedicated mobile application enabled both remote and manual control. Automated functions included irrigation, weeding, and chemical application, triggered by real-time sensor data. Results obtained from the performance testing conducted for six hours, three hours on solar power and three hours on battery. The system achieved 90% efficiency under solar power and 75% on battery. Functional success rates included 92% for remote weeding, 88% for automated irrigation, 94% for data transmission, and 95% for the security alarm. The results indicates that, the OSIKANI Farm Solution reduces manual labor, optimizes water and energy usage, and enhances productivity. Its reliance on renewable energy and low-cost components makes it a sustainable and scalable precision farming tool for smallholder farmers in both rural and urban settings.

Keywords: Solar-powered farming, automated irrigation, GSM farm alerts, precision agriculture, small-scale farming technology, renewable energy agriculture.

1.0 Introduction

Farming is very important, especially in Ghana and other parts of the world. However, modern agriculture faces many challenges such as climate change, increasing population, and limited arable land, making it harder to produce enough food (Li et al., 2020). Many farmers in Ghana still rely on manual tools and traditional practices because they cannot afford modern machinery. In rural areas, the lack of reliable electricity and internet access makes it difficult to adopt new farming technologies (Mansoor et al., 2025). To help address these issues, the OSIKANI Farm Solution was developed as a simple and affordable farming system that integrates solar energy with automation to support farmers. The system enables real-time farm monitoring, remote machine control, and efficient use of resources such as water and energy, making it especially beneficial for rural farmers without access to the national power grid or internet. Research supports the need for such solutions. Adewuyi and Afolabi (2021) demonstrated that solar-powered systems can effectively support rural farming, while Boateng et al.

(2020) highlighted the benefits of IoT-based smart irrigation systems in Ghana. Osei and Nyarko (2019) explored the use of remote-control systems in agriculture, and Jawad et al. (2017) emphasized the role of energy-efficient wireless sensor networks in precision farming. Li et al. (2020) reviewed how IoT-based irrigation and remote sensing can improve farm productivity, and Mansoor et al. (2025) discussed the integration of smart sensors in precision agriculture. Additionally, Leao et al. (2024) showcased AI-powered IoT irrigation systems for precision farming, while Mohamed Rafi et al. (2025) examined reliable IoT connectivity models for smart agriculture. OSIKANI builds on these findings to provide a cost-effective, sustainable, and scalable approach to modernizing small-scale farming in Ghana and beyond.

2.0 Materials and Methods

2.1 System Design and Construction

The OSIKANI Farm Solution, shown in Figures 1 and 2, was designed to help farmers in rural areas manage their farms more easily and efficiently. The system uses solar power so it can work in places where electricity from the grid is not reliable. A 60W solar panel charges a rechargeable lithium battery, which provides power for the whole system. The design includes DC high-torque motors to perform mechanical work, such as moving tools for weeding or spraying. The system also has sensors to measure soil moisture, temperature, and other environmental conditions.

Fig. 1 Side View of OSIKANI

Fig. 2 Front View of OSIKANI

For chemical application, the system uses a magnetic stirrer (Figure 3) to mix farm inputs before spraying them through the nozzle (Figure 4). The heart of the design is the Arduino Uno R3 microcontroller, which receives data from the sensors and controls the different devices. The Bluetooth allows the microcontroller to wirelessly communicate with a mobile app. The layout of the components and the way they connect was carefully planned so that the system is compact, easy to use, and strong enough for farm work.

2.2 Hardware and Software Implementation

The hardware was built by connecting all the components, the solar panel, battery, motors, sensors, relays, magnetic stirrer, microcontroller, and alarm system.

Fig.3 Magnetic Bar

Fig.4 Spray Nozel

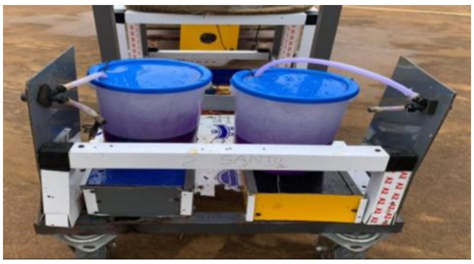

Fig. 5 Front View of OSIKANI

The wiring was done so that power flows from the battery to all parts of the system, and the sensors send signals to the microcontroller. Fig. 5 shows the arrangement of how the chemicals can be sprayed.

The alarm system is also connected to give warnings in case of intrusion. Fig. 6 shows the circuit diagram developed using TinkerCad.

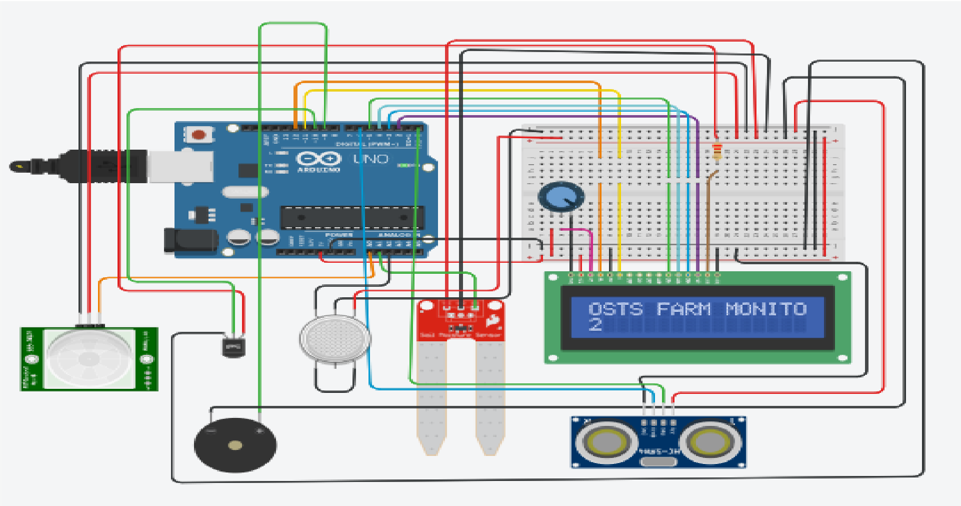

Fig. 6 Circuit for the Control

The software for the OSIKANI Farm Solution was developed using the Arduino IDE. The code allows the system to work in two modes: manual and remote. In manual mode, the farmer uses toggle switches to control the movement of the device, irrigation and weeding functions. In remote mode, the farmer can send commands through the mobile app. to perform same tasks.

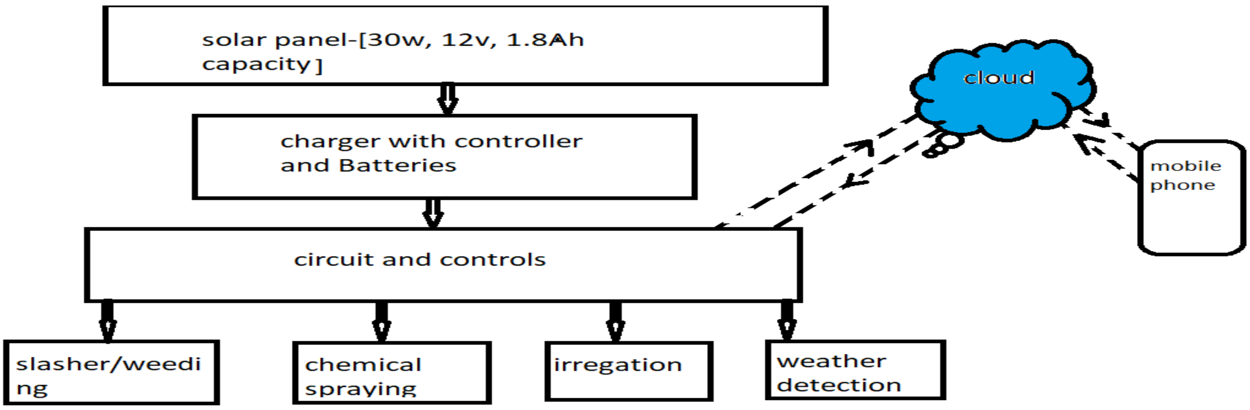

Fig. 7 system's block diagram

The soil moisture sensors can start irrigation automatically when the soil is dry, and other sensors send real-time data to the phone. The chemical spraying process is also controlled by the microcontroller, which turns on the magnetic stirrer to mix chemicals before spraying. Fig. 7 shows a block diagram of how the whole system operates.

3. Results

The OSIKANI Farm Solution was tested for a total of 6 hours under two distinct conditions: 3 hours using solar energy alone and 3 hours using battery power. Under direct sunlight, the system operated at 90% efficiency, while under battery power alone, it achieved 75% efficiency. Table 1 shows the power management performance metrics of OSIKANI Farm.

Table 1 Power and energy management performance

Functionality	Success Rate (%)
Solar-powered operation	90
Battery-powered operation	75
Continuous battery charging	93

The data shown in table 2 was obtained during the manual, remote, and automated modes. Manual operations, such as direct weeding control and chemical spraying, were reliable. Remote operations via the mobile app enabled real-time monitoring, scheduling, and instant manual activation of irrigation and other farm processes.

Table 2 Manual operation

Functionality	Success Rate (%)
Manual weeding control	90
Manual chemical mixing/spraying	88

Automation features data recorded in table 3 ensured crops were irrigated when soil moisture dropped below thresholds, chemicals were uniformly mixed for spraying, and alerts were sent for events such as irrigation completion, low water levels, and intrusions. The continuous battery charging system maintained sufficient energy during daylight hours to support uninterrupted operation.

Table 3 Remote operation, data transmission and security alarm performance

Functionality	Success Rate (%)
Remote weeding control	92
Remote irrigation control	89
Data transmission to phone	94
Auto-irrigation response	88
Chemical stirring & spraying	89
Security alarm	95

3.1 Findings

The testing confirmed that the system is highly functional in rural settings. It reduces labor, optimizes water usage, and promotes safer handling of chemicals. Its affordability and use of locally available parts make it scalable. The real-time data feature enables farmers to take informed actions, ultimately improving crop yield.

3.2 Significance and Impact

OSIKANI Farm Solution provides an accessible entry point into smart farming for smallholder farmers. It demonstrates how renewable energy, low-cost sensors, and simple automation can work together to improve productivity, sustainability, and resilience in agriculture. The system aligns with the global call for climate-smart agriculture and can be adapted for various farming needs. Future improvements include integrating artificial intelligence to personalize farm management and expanding the sensor suite to include pest detection and crop health monitoring.

4.0 Discussion

The OSIKANI Farm Solution demonstrated strong reliability in energy sourcing. Under solar power, the system achieved a 90% success rate, indicating efficient energy capture and utilization in direct sunlight. Battery-powered operation showed slightly reduced performance at 75%, likely due to voltage drops during extended use and lower discharge efficiency. The continuous battery charging feature recorded 85% effectiveness, showing that while the system can replenish energy during operations, efficiency is reduced during low-light conditions. This power performance graph shown in Figure 8 suggests that the solution can reliably operate off-grid but benefits most from consistent solar exposure.

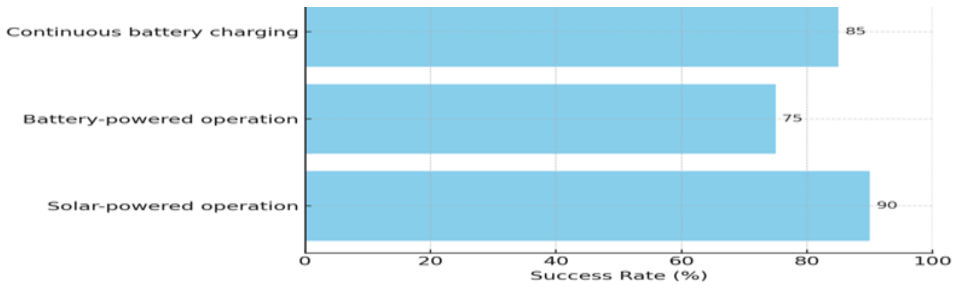

Fig. 8- power performance metrics

The farming operation features all exceeded 85% success, showing a high level of operational reliability. As illustrated in Figure 9, remote weeding control at 92% and auto-irrigation response at 88% indicate that both manual override and automated environmental triggers are dependable. Chemical stirring and spraying at 89% shows that the magnetic stirrer and sprayer deliver consistent mixtures for crop treatment. Manual operation control at 90% highlights that local user interventions work reliably when required, offering flexibility during connectivity issues. Overall, the high percentages across operations reflect robust actuator performance, sensor accuracy, and system integration.

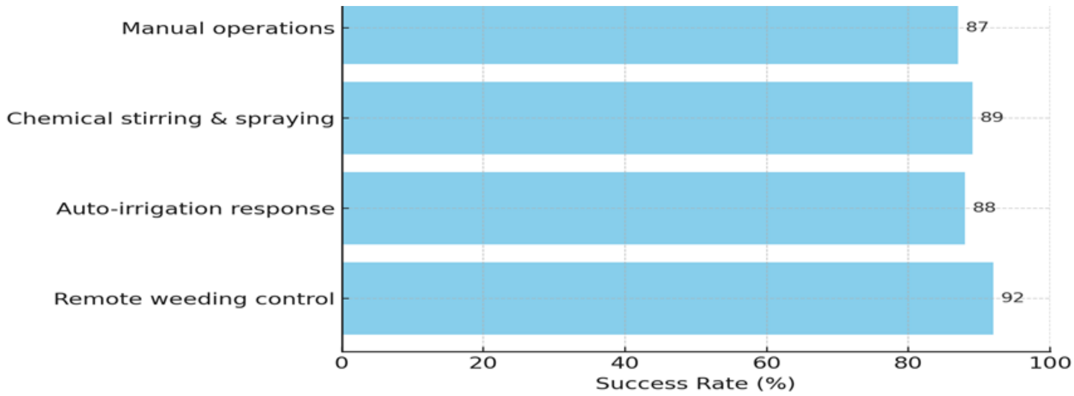

Fig. 9 Farming operations

The communication and security functions demonstrated the highest consistency. Data transmission to phone at 94% confirms reliable GSM and app-based telemetry, ensuring farmers receive timely updates. Remote operation control at 91% shows that mobile app commands are executed with minimal latency or failure. The security alarm at 95% was the top-performing metric, suggesting a strong and responsive intrusion detection system, see Figure10. These results indicate that the OSIKANI Farm Solution is well-suited for remote farming management, enabling users to monitor and control their farms even from distant locations.

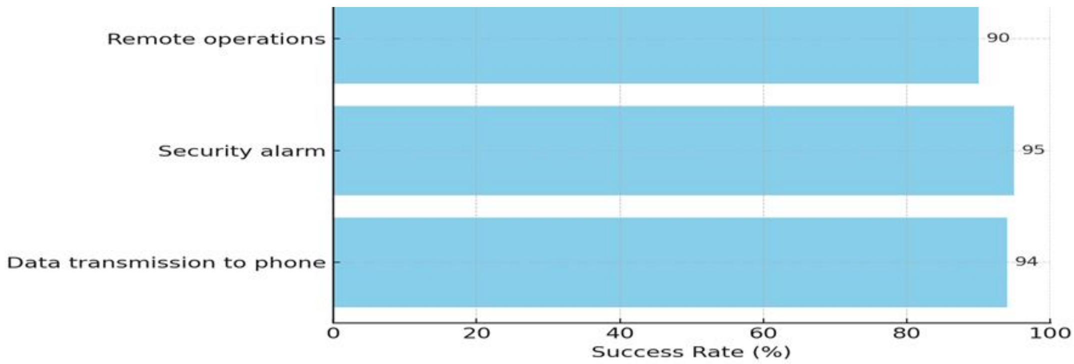

Fig.10 communication and security metrics

Overall, the system's strength lies in its automation reliability and remote accessibility. The combination of solar-battery hybrid power, accurate sensing, and integrated GSM/mobile control makes it adaptable for rural farming contexts where energy and connectivity can be inconsistent. However, the slightly lower battery-only performance and continuous charging efficiency suggest opportunities for improvement, such as larger capacity batteries, more efficient charge controllers, or supplementary energy harvesting technologies.

5.0 Conclusion

The OSIKANI Farm Solution has proven to be a reliable and efficient smart farming system capable of operating effectively under both solar and battery power. Its high performance across automated and manual operations, coupled with strong communication and security features, makes it a practical solution for precision agriculture, especially in off-grid and rural settings. The integration of GSM alerts and mobile app control ensures farmers can remotely monitor and manage their farms, reducing labour demands and improving response time to environmental changes. While battery-only efficiency and continuous charging performance could be further optimized, the overall results demonstrate that the system is robust, scalable, and well-suited to support sustainable farming practices. With minor enhancements in energy storage and management, the OSIKANI Farm Solution has the potential to deliver even greater operational reliability and long-term impact on agricultural productivity.

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