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Diverse Agriculture Machine Using IoT

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ABSTRACT :

The 'Diverse Agriculture Machine Using IoT' aims to revolutionize small-scale farming through an integrated, multifunctional agricultural system capable of ploughing, seeding, spraying, and harvesting. By incorporating IoT for real-time control and solar energy for sustainability, the machine enhances field efficiency while reducing labor dependency. The compact design, modular functionality, and remote monitoring ability via smartphone interfaces target accessibility for small and medium-scale farmers. With successful autonomous navigation and task execution, the project validates a practical, scalable, and eco-friendly solution for modern agricultural challenges

Keywords: IoT, Smart Farming, Solar-powered Agriculture, Multipurpose Agriculture Machine, Precision Farming, Autonomous Farming, Renewable Energy, Sustainable Agriculture

Introduction

Basic Introduction

Agriculture has always been central to human civilization, providing essential resources for sustenance. With the global population rising, there is an increasing demand for higher agricultural productivity. However, many regions, particularly in developing countries, still rely on traditional farming practices, which often lead to lower yields, high labor dependency, and inefficient resource utilization.

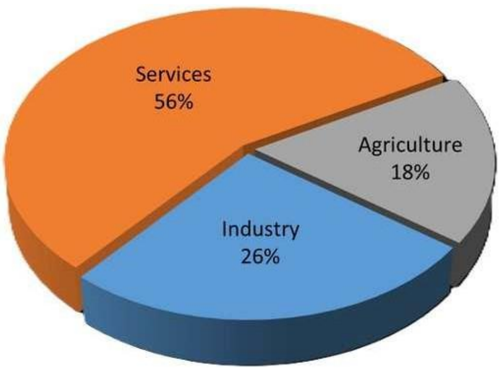


Figure 1 Contribution of Agriculture Sector to Indian Economy

Recent advancements in technology, especially in automation and digitalization, have revolutionized agriculture. The Internet of Things (IoT) is a transformative tool in this regard, enabling real-time data collection, remote monitoring, and smart decision-making. In parallel, the adoption of renewable energy sources, such as solar power, offers a sustainable alternative to fuel-powered machinery, reducing operating costs and minimizing environmental impact.

By integrating IoT and solar-powered automation, this project aims to modernize farming practices, enhancing efficiency, sustainability, and accessibility, especially for small and marginal farmers.

Need for project

Small and medium-scale farmers face several challenges, including labor shortages, high operational costs, and limited access to modern equipment. Tasks like ploughing, seeding, fertilizing, and

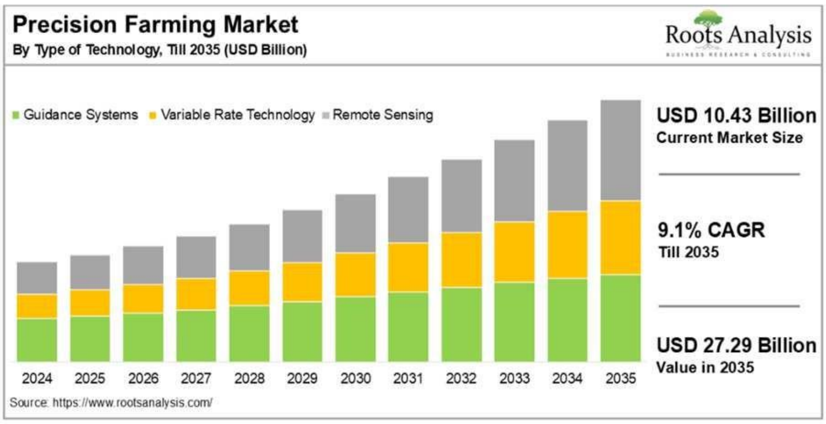
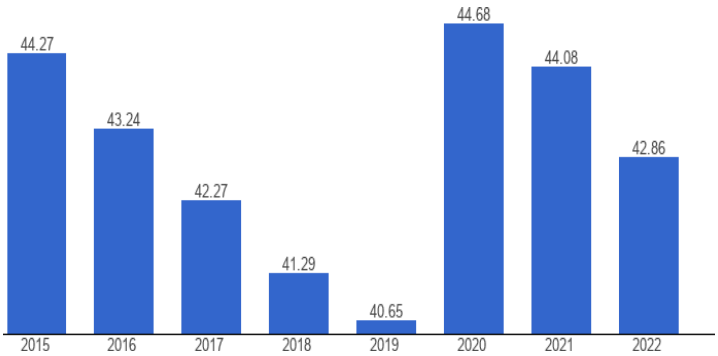


Figure 2. Growth in Precision Farming Market

harvesting require specialized machinery, which is often costly and difficult to maintain. Additionally, unreliable electricity supply in remote rural



areas makes it challenging to operate electrically powered machines.

Figure 3. Labour shortage

Literature Survey

This situation calls for an all-in-one solution capable of performing multiple farming tasks efficiently, reducing manual labor, and operating independently of the electrical grid. Integrating IoT technology enables remote monitoring and control via smartphones or computers, while solar power ensures functionality in areas with limited infrastructure and promotes eco-friendly practices. The motivation behind this project is to provide farmers with an affordable, smart, and sustainable tool that enhances productivity and alleviates the physical and financial burdens of farming.

Detailed Analysis of Reviewed Literature

2.1.1. Design and Fabrication of Motorized Multipurpose Agricultural Machine (IJAEM, June 2021).[1]

Bhandakkar, Gaurav Sukhdeve, Akshay Mankar, Dr. S. K. Choudhary.

2.1.1.1. **Methodology:**

Developed a lightweight motorized multipurpose machine for sowing, leveling, weeding, and land preparation. Powered by a 250W BLDC motor and a 12V battery, with chain-drive motion and semi-automated seed dropping.

2.1.1.2 Advantages:

- Low-cost and energy-efficient
- Easy to operate and maintain
- Reduces dependency on heavy machinery for small-scale farmers
- Multipurpose and adaptable for various soil types

2.1.1.3. Disadvantages:

- Limited power compared to tractors

Semi-automated, still needs manual input for seed operations

- May not perform efficiently on large-scale farms or in difficult terrains.

2.1.1.4. **Conclusion:**

Ideal for small landholders, the machine helps reduce labor and improves productivity. Mass production could lower costs further, addressing affordability issues in Indian farming.

2.1.2. **Multipurpose Agriculture Machine (IJCRT, July 2021).[2]**

Authors: Shivam Rai, Navneet Rai, Deepesh Yadav.

2.1.2.1. **Methodology:**

Designed for cutting residual crops (parali), spraying pesticides, and ploughing using solar-powered battery-fed motors. Hollow cone nozzles for pesticide application; blade-mounted cutters for crop residue.

2.1.2.2. **Advantages:**

- Eco-friendly and energy independent.
- Lightweight and low-cost.
- Modular design with easily attachable parts.
- Reduces dependence on fuel or electricity.

2.1.2.3. **Disadvantages:**

- Limited battery capacity affects prolonged use
- Cutting and spraying efficiency varies by crop and terrain
- Initial solar setup requires investment

2.1.2.4. **Conclusion:**

An environmentally conscious solution for organic farming, suitable for farmers lacking power grids or fuel.

2.1.3. Multipurpose Agriculture Machine (JETIR, March 2024).[3]

Authors: Sahil Shamrao Kirtane, Ansh Notani, Ali Dalvi, Sumit Laxman Waghmare.

2.1.3.1. **Methodology:**

Combined ploughing, seed sowing, and water sprinkling in a single machine. Built using a torque motor, rotating sprocket- based seed tank, and electric water pump.

2.1.3.2. **Advantages:**

- Saves cost by integrating multiple machines
- Increases sowing and irrigation efficiency
- Ideal for small landholders with limited labor

2.1.3.3. **Disadvantages:**

- Not suitable for uneven terrain or large-scale fields.
- Fixed seed spacing may reduce flexibility.
- Semi-automated with manual controls.

2.1.3.4. **Conclusion:**

Cost-effective and labor-saving tool suited for small plots, encourages automation at the grassroots.

Multipurpose Agriculture Machine (IJSREM, May 2023).[4]

Authors: Abhiyukt Singh, Krishna Mohan Sharma, Shivam Yadav

2.1.3.5. **Methodology:**

Arduino Uno–based system integrating wheel movement, water spraying, rolling, and rotating sprayers. Powered by a solar panel–battery hybrid and includes sensors.

2.1.3.6. **Advantages:**

- Supports precision agriculture via sensors.
- Customizable and programmable.
- Uses renewable energy, reducing costs.

2.1.3.7. **Disadvantages:**

- Requires technical knowledge.
- Not scalable for large farms.
- Arduino limits performance in harsh environments.

2.1.3.8. **Conclusion:**

Ideal for smart farming and experimentation, but needs strengthening for broader use.

Outcome of Literature Survey

The literature survey conducted on various multipurpose agricultural machines reveals a strong focus on low-cost, energy- efficient [1][2][4] solutions aimed at supporting small and marginal farmers. All the reviewed systems were designed to integrate multiple functions [1][2][3][4] such as ploughing, seed sowing, water/pesticide spraying, and in some cases, weeding and crop residue management, into a single unit. These machines are typically compact, lightweight, and adaptable to different crop types and terrains.

A common theme across the studies is the use of renewable energy sources such as solar power and automation with microcontrollers like Arduino [4], enabling precise operations and reducing manual labor. However, despite the innovation, most systems are semi-automated and best suited for small-scale farms, with limited scalability to large agricultural fields. Another critical observation is the frequent lack of modularity [1][2][3][4] and limited user customization in many designs.

Overall, the survey highlights the increasing relevance of multipurpose, IoT- enabled agricultural machines in rural settings. These devices offer a practical approach to solving labor shortages, reducing equipment costs, and promoting sustainable farming practices. The findings of this survey directly inform the design and functional scope of the proposed "***Diverse Agriculture Machine using IOT,***" which aims to address existing limitations through enhanced automation, improved energy management, and broader operational capabilities.

Diverse Agriculture Machine using IOT

Basic Introduction

The "Diverse Agriculture Machine Using IoT" project aims to transform small-scale farming by providing an integrated machine capable of performing multiple essential tasks, including ploughing, seeding, fertilizer spraying, and harvesting. This reduces the need for multiple machines and lessens dependency on manual labor.

The machine's innovation lies in its IoT capabilities, allowing for enhanced flexibility, efficiency, and real-time feedback. Powered by solar energy, the machine features solar panels that charge onboard batteries, enabling it to operate in off-grid areas and reducing reliance on external power sources, while promoting environmental sustainability.

Equipped with a line-following system, the machine autonomously navigates fields, ensuring precision in planting and spraying. This project offers a cost- effective, eco-friendly, and intelligent solution for small and medium-scale farmers, enhancing productivity, reducing labor, and supporting sustainable farming practices.

Problem Statement

Traditional farming methods are often labor-intensive, time-consuming, and prone to inefficiencies, leading to increased costs and reduced yields. Additionally, the variability in environmental conditions and the necessity for sustainable practices further complicate effective farm management.

Project Objectives

1. Optimize use of renewable and conventional resources to reduce pollution.
2. To reduce the physical strain experienced by farmers.
3. Implement specific agriculture practices for sustainable development.

Proposed Methodology

Block Diagram

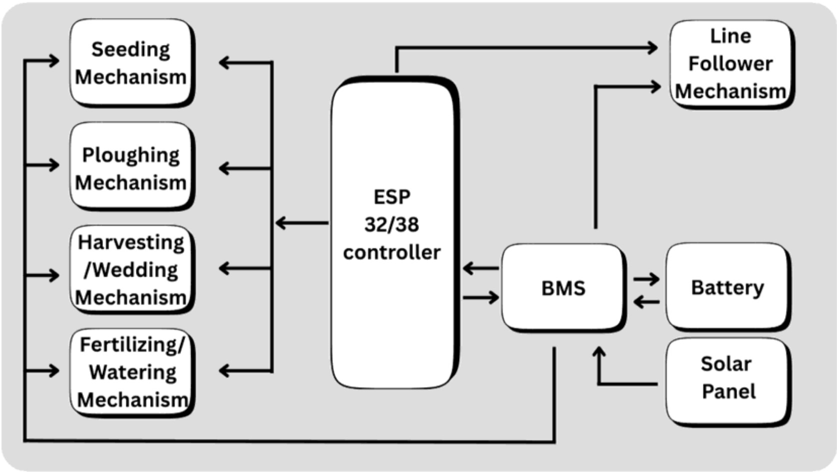


Figure 4. Proposed Block Diagram

Methodology

This project aims to develop a compact and efficient system capable of performing multiple agricultural tasks, reducing manual effort. By integrating various hardware components and programming them via a centralized controller, we created a machine that supports smart farming with improved energy management and remote operability.

1. **System Architecture and Control Design**

The core of the system is based on the ESP32 microcontroller, chosen for its dual-core processing and integrated Wi-Fi and Bluetooth capabilities. This enables real-time remote control and monitoring through a web or mobile-based IoT interface. The ESP32 manages task selection, sensor data acquisition, and control signal transmission to actuators.

2. **Mechanical and Locomotion Assembly**

The machine's frame is designed to accommodate multiple tools and facilitate easy movement across farmland. Johnson geared motors, selected for their torque efficiency and compatibility with low- voltage systems, drive the machine. Navigation is handled by a line-following mechanism, using IR sensors for path tracking and ultrasonic sensors for obstacle detection and avoidance. The machine halts automatically upon detecting an obstacle.

3. **Task-Specific Actuation**

Task-specific modes (seeding, ploughing, harvesting, fertilizing, watering) activate corresponding servo motors. Each servo- driven mechanism is precisely controlled by the ESP32, ensuring efficient operation and minimizing manual intervention.

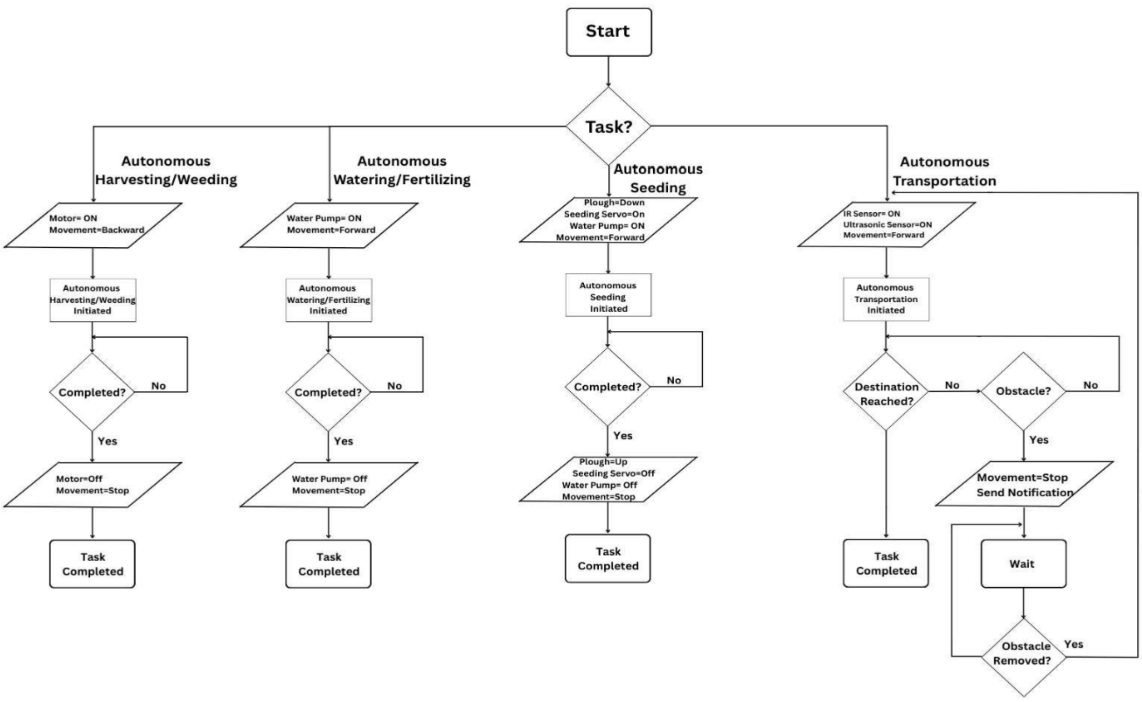
4. **Power Supply and Energy Management**

Powered by a rechargeable 18650 Li-ion battery, the machine offers a lightweight, high-energy-density power source. Solar recharging is supported through an integrated photovoltaic module, ensuring continuous operation in remote areas with limited power access.

5. **Communication and User Interface**

The machine's status and control commands are managed through an IoT platform, including Wi-Fi-based mobile apps or cloud dashboards. Users can select tasks via this interface, enabling intuitive, remote operation.

Proposed Flowchart



Advantages and Disadvantages

Advantages:

- Reduced manpower/labor requirement: These machines automate tasks like plowing, sowing, harvesting, and spraying, which traditionally require a lot of manual labor. This is especially useful in areas with labor shortages or high labor costs.
- Uses clean and renewable energy: By using solar panels, the machine operates on renewable energy instead of fossil fuels, reducing the carbon footprint and reliance on non-renewable resources.
- Energy efficient: The integration of IoT and optimized systems ensures minimal energy wastage. Devices work smartly, activating only when needed and operating efficiently.
- Helps in sustainable development: Promotes long-term agricultural practices that are environmentally friendly and resource-conserving, which is essential for future generations.
- Reduced air pollution and soil acidity: Since the machine does not rely on diesel or petrol, it emits no harmful gases. Also, it avoids excessive chemical use, preventing soil degradation and maintaining soil health.

Disadvantages:

- High Initial Cost: The initial investment for building or buying such an advanced machine is high due to the cost of IoT components, solar panels, sensors, and embedded systems. This can be a barrier for small-scale farmers.
- Dependence on Internet & Power: Many IoT-based features require continuous internet access and power. In rural or remote areas, this connectivity may be unreliable
- or unavailable, affecting machine functionality.
- Farmer Training Requirement: Farmers need to learn how to operate and maintain the machine, understand data from IoT systems, and troubleshoot basic issues. This can be challenging, especially for older or less tech-savvy farmers.

Summary

The project titled **"Diverse Agriculture Machine Using IoT"** presents an innovative solution aimed at transforming traditional farming methods by integrating modern technologies such as the Internet of Things (IoT) and solar power. This multifunctional machine is designed to perform key agricultural operations— ploughing, seeding, fertilizer spraying, and harvesting—using a single system, thereby reducing the need for multiple machines and minimizing dependency on manual labour.
The machine is equipped with IoT capabilities, allowing remote control via smartphones or web interfaces. This enhances operational efficiency. Additionally, it features solar panels for powering its motors and electronics, making it ideal for off-grid and rural areas with unreliable electricity supply.
To ensure precision and automation, a line-following system is incorporated, enabling the machine to navigate fields autonomously. Overall, this project offers a cost-effective, sustainable, and intelligent farming solution tailored for small and medium-scale farmers. It aims to boost agricultural productivity, promote eco-friendly practices, and empower farmers with accessible, modern technology.

Result and Discussion

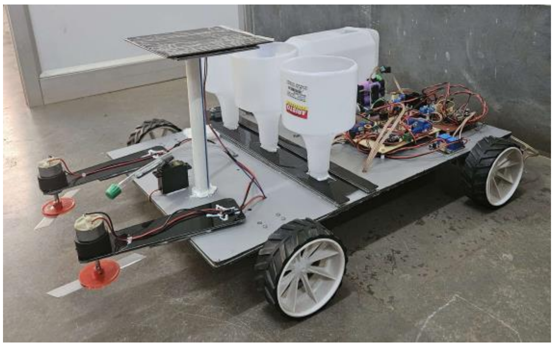


Figure 6. Diverse Agriculture Machine using IOT model

Result

In this project, the ***Diverse Agriculture Machine using IoT*** was fabricated and tested to evaluate its functionality across core agricultural tasks and autonomous transport. The following results were observed:

4.1.1 Manual Task Performance:

- Ploughing: The machine achieved consistent soil furrow depths in loamy field conditions, matching design specifications.
- Seeding: Seed placement accuracy was measured at ±2 cm spacing, ensuring uniform germination potential.

- Harvesting Simulation: The servo- actuated cutter demonstrated repeatable actuation cycles, without mechanical failure. repeatable actuation cycles, without mechanical failure.

4.1.2. Autonomous Transportation:

- Line-Following Accuracy: The machine successfully navigated a predefined track with 98% sensor recognition accuracy, using IR for line detection and ultrasonic sensors to avoid obstacles.

4.1.3. Battery Endurance: The 18650 Li-ion pack sustained continuous operation—combining task execution and transport—for approximately 2 hours, closely aligning with theoretical capacity estimates.

4.1.4. IoT Integration and User Interaction:

- Connectivity Stability: The ESP32 maintained a stable Wi-Fi connection with less than 1% packet loss during dashboard monitoring on the Blynk Web and Mobile applications.
- Remote Control Responsiveness: Command latency averaged 150 ms, enabling near real-time actuation of tasks from the mobile interface.

Discussion

The experimental data demonstrates that the ***Diverse Agriculture Machine using IoT*** meets its design objectives for small- scale agricultural operations. **Manual task modules** (ploughing, seeding, harvesting) operated within acceptable tolerances, indicating robust mechanical design and servo control.

Autonomous transport was reliable under controlled conditions, though performance will require validation on varied terrains and longer track lengths. The **battery life** suggests suitability for short-duration field sessions but could be improved via higher-capacity cells or enhanced solar recharging.

Finally, **IoT integration** via ESP32 and Blynk provided a responsive and user- friendly control interface. Future iterations could explore MQTT protocols for improved scalability and implement edge computing for localized decision-making, reducing latency and dependency on cloud services.

Overall, the results validate the core concept of an IoT-enabled multipurpose agricultural machine, confirming its potential for real-world deployment in resource-constrained farming contexts.

Conclusion and Future Scope

Conclusion

The project titled “***Diverse Agriculture Machine using IoT***” addresses a critical need in the agricultural domain— developing an affordable, multifunctional, and technology-enabled solution to assist small and marginal farmers in managing essential field operations. Through an extensive literature survey and technical analysis, it is evident that existing multipurpose agricultural systems have demonstrated significant advantages in terms of reducing manual labor, minimizing costs, and improving efficiency. However, many of these systems lack automation, modularity, and adaptability to diverse field conditions.

The Diverse Agriculture Machine using IoT overcomes these gaps by combining core agricultural operations—such as ploughing, seed sowing, spraying, and irrigation—into a single, compact platform integrated with IoT-based control. The proposed system not only simplifies field operations but also enhances precision and resource management by leveraging real-
time automation. As a result, the project lays the foundation for a smart, cost- effective, and scalable farming solution aligned with the goals of sustainable and modern agriculture.

Future Scope

The Diverse Agriculture Machine using IoT presents promising opportunities for future expansion and refinement. The following are key directions in which the system can be developed further:

1. **Integration of Smart Sensors and AI Algorithms:**

Future iterations can include AI-driven decision-making supported by real-time sensor data to autonomously adjust operations such as sowing depth, watering frequency, or spraying intensity.

2. **Cloud Connectivity and Data Logging:**

Incorporating cloud platforms for data storage and analysis can help farmers track performance trends over time and receive predictive insights based on weather patterns and crop health data.

3. **Precision Agriculture Tools:**

Adding tools such as soil nutrient sensors, pH sensors, and drone-based aerial imaging can enhance field analysis and enable location-specific action, thereby improving crop yield and reducing input waste.

4. **Mobile App Interface:**

A user-friendly mobile application can allow farmers to monitor machine status, receive alerts, and control operations remotely, improving accessibility and control.

5. **Expandable Mechanical Design:**

Future models can include interchangeable attachments for harvesting, soil testing, and fertilizer application, enhancing the versatility and lifecycle of the machine.

6. **Energy-efficient Power Management:**

Hybrid solar-electric power systems and optimized battery management can be introduced to support longer operation durations and improve energy sustainability in off-grid regions.

Commercial Deployment and Pilot Testing: The system can be tested in real farm environments across varied geographical locations to validate performance, gather user feedback, and adapt the design for widespread adoption.
In summary, the Diverse Agriculture Machine using IoT serves as a strong stepping stone toward intelligent and sustainable agricultural mechanization. With further development and field validation, it holds the potential to revolutionize small-scale farming practices and bridge the technology gap in rural agriculture.

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