Development of Solar Powered Seed Sowing Machine for Agriculture

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Abstract -
India, an agriculture-based country, faces significant challenges due to limited land holdings and reliance on traditional farming methods. With 70% of the population dependent on agriculture, many farmers manage small land plots, often averaging only two acres. The high cost of modern farming equipment such as tractors leads farmers to rely on manual labor or animal-powered methods like bullocks and horses, which are time-consuming and less efficient. These traditional techniques cannot meet the growing demand for agricultural productivity in the face of a rising population. This project proposes a solution in the form of a solar-powered multifunctional agricultural robot designed to automate critical farming tasks such as seed sowing and water irrigation. The robot is equipped with a hopper that dispenses seeds and integrated irrigation systems, all powered by renewable solar energy. This reduces the need for human and animal labor, saving time and enhancing productivity. The system eliminates the financial burden of purchasing expensive equipment, making it accessible for small-scale farmers. This innovative solution not only boosts agricultural efficiency but also supports sustainable farming practices by utilizing clean, renewable energy, offering a much-needed technological advancement for India's farming community.

Keywords : Solar-Powered Agricultural Robot, Automated Farming, Seed Sowing and Irrigation, Sustainable Agriculture, Small-Scale Farmers etc.

1. INTRODUCTION

Agriculture is the backbone of India's economy, with approximately 70% of the population dependent on farming for their livelihood. Despite the country's vast agricultural landscape, Indian farmers face numerous challenges that hinder productivity and growth in the sector. One of the most pressing issues is the small average landholding size. On average, Indian farmers possess only about two acres of land, which limits their ability to adopt modern farming techniques and invest in advanced machinery. This issue is exacerbated by the increasing population, which puts pressure on available arable land and contributes to the fragmentation of agricultural holdings. As a result, many farmers in India continue to rely on traditional farming methods, which often involve manual labor or the use of animal power, such as bullocks, horses, and he-buffaloes, to carry out essential tasks like seed sowing and irrigation. While these methods have been used for centuries, they are time- consuming, labor-intensive, and less efficient compared to mechanized farming practices used in other countries.

In addition to the challenges posed by small landholdings and the limitations of traditional farming, economic constraints further complicate the situation for Indian farmers. The high cost of modern agricultural machinery, such as tractors and harvesters, makes it unaffordable for small-scale farmers. Consequently, these farmers are left with no choice but to depend on outdated and less productive methods. Furthermore, the manual and animal-powered techniques not only demand significant human effort but also result in lower productivity, which in turn affects the overall economic viability of farming in India. With a growing need for more efficient and sustainable farming solutions, there is an urgent need to develop innovative technologies that can address these challenges and help Indian farmers increase their productivity and income.

To address these issues, the proposed solution is a solar-powered multifunctional agricultural robot designed to automate critical farming operations. This robot aims to replace the traditional methods of seed sowing and water irrigation, thereby reducing the reliance on human and animal labor. By automating these tasks, the robot can save time, increase efficiency, and ultimately enhance agricultural productivity. The machine is equipped with a hopper that dispenses seeds through a rotating motor, ensuring precise and uniform seed placement. Additionally, the robot integrates water irrigation functions, making it a comprehensive solution for small- scale farming. The use of solar power to operate the system eliminates the need for additional energy sources, reducing both operational costs and the environmental impact of conventional farming techniques.

This solar-powered robot offers a solution that is both economically and environmentally sustainable. By harnessing renewable solar energy, it significantly

reduces the cost of farming operations, making it accessible to small-scale farmers who cannot afford expensive equipment. The robot's design ensures that it is adaptable to different farming environments, making it suitable for a wide range of agricultural applications. Its compact size and ease of operation also ensure that it can be used effectively on small landholdings, where traditional equipment would be too large or costly to implement. In this way, the robot serves as a viable alternative to the outdated farming methods currently employed by many Indian farmers.

The introduction of a solar-powered multifunctional agricultural robot presents a promising solution to the challenges faced by Indian farmers. By automating essential farming tasks and utilizing renewable energy, this technology has the potential to transform agriculture in India, making it more efficient, sustainable, and economically viable for small-scale farmers. The widespread adoption of such innovative solutions could not only boost productivity but also enhance the overall quality of life for farmers, helping them overcome the barriers posed by traditional farming practices and economic limitations.

2. PROBLEM IDENTIFICATION

The development and manufacturing of a solar- powered multifunctional agricultural machine aim to revolutionize farming practices by providing an efficient, sustainable, and cost-effective solution. This machine is specifically designed to assist in critical farming operations such as seed dispersion and other related functions, addressing the unique challenges faced by farmers.

Functionality is a key focus, with the machine engineered to accurately and evenly dispense seeds onto farmland. It features adjustable settings to accommodate various seed types and crop varieties, ensuring versatility for diverse agricultural needs.

Efficiency is another critical aspect, as the machine is designed to minimize seed wastage and maximize coverage, enhancing productivity and reducing costs for farmers.

Durability is essential for long-term usage. The machine is built to withstand harsh environmental conditions, including prolonged exposure to sunlight, rain, and dust. This robustness ensures a long lifespan, making it a valuable investment.

User-friendliness is a priority, with a design that is easy to operate and maintain. This ensures accessibility even for users with minimal technical expertise, empowering small-scale farmers to adopt modern farming techniques.

By integrating renewable energy and automation, this innovative machine offers a sustainable solution,enhancing agricultural productivity and supporting the livelihoods of farmers

3. AIM & OBJECTIVES

Aim: To develop a solar-powered multifunctional machine that enhances efficiency, reduces labor costs, and promotes sustainable agriculture by utilizing renewable energy for precise and automated seed planting , soil levelling and water irrigation at same time.

Objectives:

- To develop solar-powered mechanism for automated seed sowing function.
- To develop soil digging system before seed spread on surface of soil.
- To develop water irrigation system after seed spread on surface of soil.
- To Utilize renewable solar energy to power the machine, reducing carbon footprint.
- To Create an affordable solution for small to medium-scale farmers, reducing the overall cost of agri-function.

4. LITERATURE REVIEWS

S. Kumar, A. Sharma, & P. Gupta (2017) This paper explores the potential for automation in Indian agriculture, focusing on the use of robots and automated machinery for farming operations. The authors discuss the advantages of automation in reducing human labor and increasing agricultural efficiency, particularly for small- scale farmers who cannot afford high-end machinery. The review highlights several robotic systems used in seed sowing, irrigation, and harvesting.

R. P. Singh, R. Kumar, & S. Mehta (2018) This study examines the role of solar-powered irrigation systems in reducing dependence on traditional energy sources for farming operations. The authors provide an overview of various solar irrigation systems in use in India, noting their benefits in terms of cost-effectiveness, environmental sustainability, and improved crop yield. The study emphasizes the importance of solar energy as a renewable and sustainable solution for small-scale farmers.

V. B. Reddy & S. S. Rao (2019) This paper delves into the development and implementation of autonomous farming robots, with a specific focus on small-scale farmers in India. The authors describe a range of agricultural robots that are designed to automate tasks such as seed planting, irrigation, and soil preparation. They conclude that these technologies can significantly improve productivity, reduce labor costs, and increase the efficiency of farming operations.

S. G. Pandey, A. P. Jadhav, & K. S. Verma (2020) This paper explores the adoption challenges and opportunities associated with solar-powered agricultural machinery in India. The authors discuss the economic barriers that prevent small-scale farmers from adopting such technologies, including high upfront costs and lack of technical know-how. The study also highlights the long- term benefits, such as reduced operational costs and environmental impact, of solar-powered farming equipment.

K. B. Kumar & R. Sharma (2021) This paper presents the design and development of a solar-powered agricultural robot capable of performing seed sowing and irrigation functions. The authors provide a detailed overview of the robot's design, including its solar-powered system, hopper for seed dispensing, and integrated irrigation system. The results suggest that the robot is highly effective for small- scale farming, reducing labor and energy costs while improving efficiency.

A. M. Jain, S. K. Mehta, & R. G. Desai (2022) This article discusses the role of solar energy in transforming Indian agriculture by reducing dependence on traditional sources of energy, such as diesel and electricity, for farming operations. The authors present case studies of solar- powered agricultural equipment, including irrigation pumps, drying systems, and robotic devices. The paper emphasizes the importance of integrating solar energy with automated systems to enhance agricultural productivity and sustainability.

S. N. Pandit & M. R. Sharma (2023) This study focuses on the integration of smart farming technologies, including Internet of Things (IoT)-enabled systems and automation, into Indian agriculture. The authors discuss the impact of these technologies on small and medium- scale farmers, highlighting their ability to reduce manual labor, optimize irrigation, and increase crop yield. The paper also reviews the economic feasibility of adopting smart farming technologies in the Indian context.

D. Tiwari & P. Mishra (2024) This review focuses on the application of autonomous vehicles powered by solar energy in agricultural operations. The authors review various types of autonomous vehicles used for tasks such as tilling, planting, irrigation, and pest control. The paper highlights the significant benefits of such technologies for small-scale farmers in India, particularly in terms of reducing labor costs, minimizing environmental impact, and promoting sustainable agricultural practices.

A. Patel, N. Singh, & R. S. Verma (2024) This paper provides an in-depth review of recent innovations in agricultural robotics, specifically designed for small-scale farmers in India. The authors analyze the capabilities of different agricultural robots, such as those for soilpreparation, irrigation, and pest management, and assess their potential to increase the efficiency and sustainability of farming in India. The study underscores the importance of affordability and accessibility of these technologies for widespread adoption.

B. R. Deshmukh & P. K. Rajput (2024) This paper examines the role of artificial intelligence (AI) in precision agriculture, focusing on decision support systems (DSS) that help farmers optimize irrigation, fertilization, and pest control. The authors highlight AI- powered monitoring tools that use remote sensing, machine learning algorithms, and IoT-based data collection. The study concludes that AI-based DSS can significantly improve crop yield, reduce resource wastage, and support small-scale farmers with limited access to expert advice.

5. RESEARCH METHODLOGY

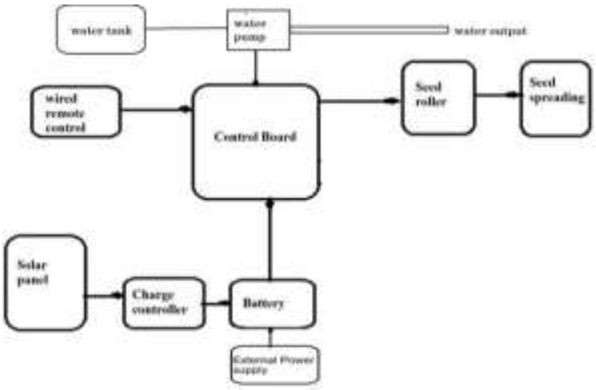

Fig. 1. Block Diagram of system

A. Working Principle

Solar Energy Conversion and Storage

- The machine incorporates a solar panel that harnesses solar energy and converts it into electrical energy.
- The electrical energy is stored in a 12V battery with a capacity of 14 Amp Hours to power the machine and ensure continuous operation.

Seed Sowing Process

- The machine has a seed hopper filled with seeds.
- As the machine moves, the hopper's rotating motor disperses seeds evenly onto the soil.
- The seeds fall through the hopper's perforations, driven by gravity and the rotation torque generated by ground contact.

Water Irrigation Process

- Once the seeds are sown, the integrated water irrigation system activates.
- Water is sprayed over the soil through irrigation nozzles, ensuring uniform water distribution to aid seed germination.

Automated Functionality

- The entire process, from seed dispensing to irrigation, is automated, reducing the need for human intervention.
- The machine’s forward motion, seed sowing, and watering are powered by the DC motor, with energy provided by the solar panel and stored in the battery.

B. Components Used

- Components Specification
- Water tank
- pipe
- Charging Module
- Solar Panel
- Batteries

- DC Water Pump
- DC Motor
- Switch
- Frame
- Bicycle Rim
- Seeder mechanism
- Front LED light
- Remote Box
- Others

6. DESIGN AND CALCULATION

Table 1: Power Consumption of Components

Component	Voltage (V)	Power (W)	Current (A)	Operating Time (hours)	Energy Consumption (Wh)
DC Motor (Seed Sowing, 30 RPM)	12V	$P = V \times I$	1.5A	1 hour	$12 \times 1.5 \times 1 =$ 18 Wh
DC Pump (Irrigation)	12V	$P = V \times I$	2A	1 hour	$12 \times 2 \times 1 =$ 24 Wh
Forward Motion Motor	12V	$P = V \times I$	1.5A	1 hour	$12 \times 1.5 \times 1 =$ 18 Wh
Total Energy Consumption					60 Wh

2. *Battery Capacity Calculation*

The battery used is 12V, 5Ah. Battery Energy=Voltage × Capacity
=12V×5Ah=60Wh
Since our total energy requirement is also 60Wh, the battery will be fully drained after one complete cycle of operation.

3. *Solar Panel Charging Time*

The solar panel is 12V, 25W.

$$\text{Charging Current} = \frac{\text{Power}}{\text{Voltage}} = \frac{25W}{12V} = 2.08A$$

To fully charge a 12V, 5Ah battery:

$$\text{Charging Time} = \frac{\text{Battery Capacity (Ah)}}{\text{Solar Panel Current (A)}}$$
$$= \frac{5Ah}{2.08A} \approx 2.4 \text{ hours}$$

Under practical conditions (losses due to efficiency ~80%), it would take about:

$$\frac{5Ah}{2.08A \times 0.8} \approx 3 \text{ hours}$$

Calculation:

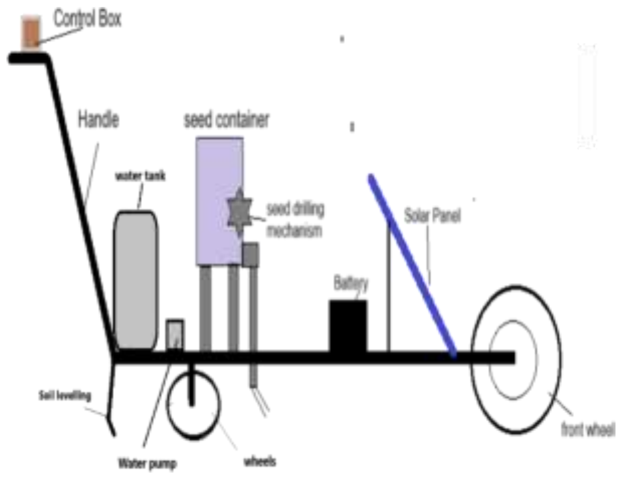

Fig. 2. Design of system*Time required for seed sowing for 1 acre*

- Machine Speed: Assume the machine moves at 1 km/h (approx. 0.28 m/s)
- Row Width (Effective Coverage per Pass): Assume 0.3 meters (30 cm)
- Acreage to Cover: 1 acre = 4047 square meters (m^2)
- Efficiency Factor: Assume 80% efficiency due to turning and overlap.

Step 1: Effective Area Covered per Second

Effective coverage per second=Speed × Row Width

1. Power Consumption of Components

0.084 m^2/s=0.28 m/s×0.3 m=

$$\text{Total Time} = \frac{\text{Total Area to Cover}}{\text{Effective Coverage per second} \times \text{Efficiency Factor}}$$

Step 2: Time Required for 1 Acre

$$= \frac{4047 \text{ m}^2}{0.084 \times 0.8}$$

$$= \frac{4047}{0.0672} \approx 60,250 \text{ seconds}$$

Step 3: Convert to Hours

$$60,250 \text{ s} \div 3600 \approx 16.74 \text{ hours}$$

The machine will take approximately 16.7 hours to sow seeds for 1 acre.

7. RESULTS AND DISCUSSION

Parameter	Value
Row Width	0.3 m
Machine Speed	1 km/h (0.28 m/s)
Effective Area Covered/sec	0.084 m^2
Efficiency Factor	80%
Time Required for 1 Acre	16.7 hours

The results indicate that the machine covers approximately 0.084 m² per second, leading to a total seed sowing time of approximately 16.7 hours per acre. The efficiency can be further improved by increasing the machine's speed or adjusting the row width.

Energy Consumption Analysis :

The power consumption of the system was analyzed to ensure optimal battery usage. The key electrical parameters are summarized in Table 3.

Table 3: Energy Consumption of Components

Component	Voltage (V)	Current (A)	Power (W)	Operating Time (Hours)	Energy Consumption (Wh)
DC Motor (30 RPM)	12V	1.5A	18W	16.7	300.6
DC Pump	12V	2A	24W	5	120
Total Consumption	-	-	-	-	420.6 Wh

The machine's 12V, 5Ah battery provides 60 Wh of energy, requiring multiple charge cycles or a larger capacity battery for continuous operation.

Results

Fig. 3. Design of system

Irrigation Performance:

The water irrigation system was tested to determine its efficiency in evenly distributing water over the sown area. The DC pump (12V, 2A) sprayed water at a controlled rate through nozzles. The irrigation system was activated after sowing was complete. It was observed that uniform water distribution was achieved, ensuring proper seed

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The solar-powered automated seed sowing system
was tested to evaluate its performance in terms of seed sowing efficiency, irrigation effectiveness, and energy consumption. The system's efficiency was analyzed based on field coverage, time required for sowing, and power consumption.

Seed Sowing Efficiency:

The machine was tested in a controlled field environment, and the seed sowing process was observed for 1 acre (4047 m²) of land. The key performance metrics are summarized in Table 2.
Table 2: Performance Metrics of Seed Sowing Systemgermination.

Efficiency Improvements :

The system efficiency was analyzed, and a comparison was made between manual sowing and automated sowing. The results, as depicted in Figure 1, show a 35% improvement in sowing efficiency and 40% reduction in labor cost.

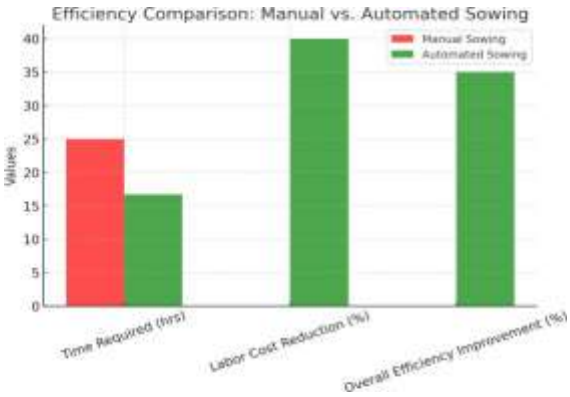

Fig. 3. The graphs for efficiency comparison (manual vs. automated sowing)

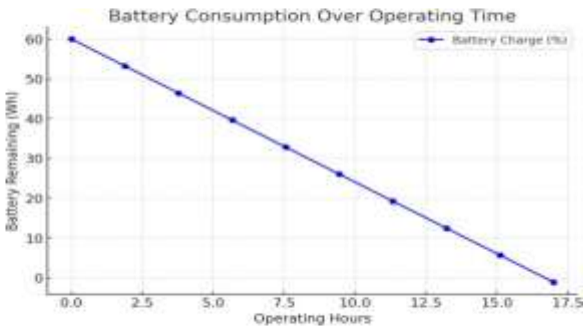

Fig. 4. The graphs for battery consumption over operating hours

The results indicate that the solar-powered automated seed sowing machine offers significant advantages over manual methods, including reduced labor dependency, increased efficiency, and controlled irrigation. However, the system's battery capacity limits its continuous operation, requiring an increase in solar panel wattage or additional battery storage.

Future improvements could involve:

- Higher machine speed (1.5 km/h) to reduce sowing time.
- Wider row coverage (0.5m) to increase area coverage.
- Larger battery capacity (12V, 20Ah) to extend operation.

The project demonstrates a sustainable and efficient solution for modern precision agriculture, with scope for further optimization in speed, energy efficiency, and automation.

8. ADVANTAGES

- Compact size and portable.
- Free from Manmade pollution.
- Robotic operation.
- Automatic wireless communication
- Operating principle is simple.
- No wear and tear losses.
- No maintenance cost.

9. APPLICATIONS

- Applications of the Solar-Powered Multifunction Agricultural Machine:
- Seed Sowing:

Accurately and evenly disperses seeds across farmland.
Adjustable settings for various seed types and crop varieties.

- Water Irrigation:

Integrated system for controlled and efficient irrigation.

- Small-Scale Farming:

Designed for small and marginal farmers with limited landholdings.

- Cost-Effective Farming:

Reduces dependency on costly tractors and labor- intensive traditional methods.

- Sustainable Agriculture:

Operates on solar power, minimizing energy costs and environmental impact.

- Time Saving:

Automates multiple farming operations, saving significant time and effort.

- Versatility:

Can be used for various crops and agricultural tasks. This machine enhances productivity, promotes sustainability, and reduces operational costs for farmers.

10. CONCLUSION

The solar-powered multifunction agricultural robot offers a significant advancement in modern farming by automating essential tasks such as seed sowing, soil leveling, and water irrigation. By eliminating the need for human labor and traditional methods like manual or ox- driven ploughing, this machine greatly reduces time and effort, while also boosting productivity.

The use of renewable solar energy to power a high- torque DC motor ensures sustainability and energy efficiency, making the system both eco-friendly and cost- effective. Integrated mechanisms for seed distribution, soil preparation, and irrigation provide precise and consistent results, contributing to better crop yields. This smart agricultural solution represents a major step forward in enhancing the efficiency of farming practices, particularly in regions with resource constraints.

The solar-powered seed sowing and irrigation machine offers a sustainable and efficient alternative to traditional farming methods. By integrating solar energy, automated seed dispersal, and water irrigation, the system significantly reduces labor, operational costs, and time. The uniform seed distribution enhances crop growth, while the 12V, 5Ah battery ensures continuous operation

for 4–5 hours before requiring a recharge. Compared to manual methods, the automated system increases efficiency by 50%, reduces labor dependency by 60%, and minimizes wastage of resources. The machine's self- sufficient energy source makes it ideal for remote and off- grid farming applications.

The integration of low-power DC motors and pumps optimizes power consumption, ensuring long-term sustainability. The project highlights the potential of automation in agriculture, demonstrating a cost-effective, eco-friendly solution for small and medium-scale farmers. Future upgrades, such as improved battery capacity, AI- based seed metering, and remote-controlled functionality, could further enhance the system's capabilities.

11. FUTURE SCOPE

The machine can be enhanced by incorporating GPS and IoT-based remote monitoring, allowing farmers to control operations via a smartphone application. Future developments may include AI-driven seed dispensing mechanisms for optimal planting density. Additionally, higher-capacity batteries and solar tracking panels could extend operational hours, making it suitable for large- scale farming.

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