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# Energy – Efficient Agricultural Robot for Smart Farming

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***ABSTRACT***

This project is about designing and building a solar-powered multipurpose agricultural robot (Agribot) that helps make farming smarter, easier, and more efficient. The main aim of this project is to use Internet of Things (IoT) technology and solar energy to reduce manual labor, save resources and increase yield of crops. The Agribot runs on solar panels, which means it does not need fuel or electricity from outside, making it eco- friendly and cost-effective. The robot uses different sensors to sense the humidity content moisture present in soil and temperature sensors to collect real-time data from the field. This data helps the farmer monitor and control farming activities using a mobile or web application through Wi-Fi or Bluetooth. As this Agribot can perform tasks like seed sowing, watering, weed cutting, spraying pesticides or fertilizers, and avoiding obstacles while moving around the field. By automating these tasks, the robot saves time, reduces human effort, and most efficient.

***Keywords:*** *Agricultural Robot, Fertilizer Sprayer, Humidity detection, IOT-Based Agriculture, Pesticide sprayer, Solar powered, soil moisture detection, Water sprayer.*

## INTRODUCTION

The integration of the Internet of Things (IoT) with renewable energy technology has marked the beginning of new phase of Smart Farming where the Multipurpose Agricultural Robot (Agribot) plays a key role. This advanced system has been developed to overcome major issues in modern agriculture including the shortage and high cost of labour rising input expenses, inefficient use of resources and the growing demand for increased crop productivity.

### 1. The Need for Automation in farming:

Older farming systems are marked by a strong dependence on manual work and limited use of modern technology. Furthermore, practices like blanket application of water, fertilizers and pesticides lead to significant resource wastage and environmental degradation. The goal of smart farming is to transition from these traditional, reactive methods to a proactive, data-driven approach known as Precision Agriculture.

### 2. Core Technological Integration

The multipurpose agricultural robot is a physical manifestation of this transition, built upon three foundational technologies:

#### A. Internet of Things (IoT) for Intelligence

The robot functions as a network of connected "things" in the field. It is equipped with an array of sensors (e.g., soil moisture, pH level, temperature, humidity) that collect real time data on crop and environmental conditions.

This data is transmitted wirelessly to a central cloud server, allowing farmers to remotely monitor field status via a mobile or web application. The IoT connectivity enables the robot to make autonomous, data-informed decisions on tasks like targeted irrigation or pest control.

#### B. Solar Energy for Sustainability

To ensure continuous operation and promote environmental sustainability, the robot is primarily powered by solar photovoltaic (PV) panels. This feature is especially critical for operation in remote farm areas with limited or unreliable access to grid electricity. By harnessing clean, renewable energy, the system significantly reduces operational costs, eliminates the need for fossil fuels, and minimizes the environmental impact of agricultural activities contributes significantly to carbon emissions.

#### C. Multipurpose Robotic Platform

Unlike single-function machinery, this robot is designed for versatility. It is equipped with various actuators and mechanisms to perform multiple tasks, including: Soil Preparation (Ploughing/Digging) Agribot [Document title] 3 Precision Seeding (Sowing seeds at optimal depth and spacing) Weed/Grass Cutting Targeted Spraying (Pesticides or fertilizers) Water Sprinkling/Irrigation.

### 3. Benefits and Impact

The combined integration of IoT, solar power, and robotics results in several transformative benefits for the agricultural sector.

**Increased Efficiency and Productivity:** Automation allows for quicker, more consistent completion of tasks, reducing overall cultivation time and labor dependence.

**Resource Optimization:** Using real time sensor data precision targeting enables water and fertilizers to be delivered exactly where and when required significantly minimizing waste and improving resource efficiency.

**Enhanced Sustainability:** The use of clean solar energy and reduced chemical runoff contributes to an environmentally friendlier farming model.

**Remote Management:** Farmers can monitor and control all operations from a distance, improving convenience and enabling timely intervention regardless of location. In conclusion, the Smart Farming Robot represents a major technological leap, providing a robust, efficient, and sustainable solution that promises to increase profitability for farmers while ensuring food security for the future.

## METHODOLOGY

The methodology of the design of Agribot describes the systematic approach utilized for performing agricultural operations through automation and wireless control. Power acquisition is achieved using a solar panel that harvests solar energy.

The generated electrical energy is regulated by a charging controller and stored in a battery, which supplies continuous and provides electrical power to the complete system. This ensures uninterrupted function of robot and provides appropriate power levels to both the microcontroller unit and the motor drive circuits.

Operational commands such as movement, digging, seed sowing, pesticide spraying, and watering are provided by the user through a wireless remote control interface. These commands are transmitted wirelessly and received by the Wi-Fi module, which forwards the command data to the central controller.

The microcontroller unit acts as the central processing unit of the system. It decodes the incoming signals, applies the programmed control logic, and generates specific low-power digital control signals for the output blocks.

The generated control signals are transmitted to the DC motor block through the motor driver circuit. The motor driver converts the low-power signals from the microcontroller into high-power electrical currents required to drive the motors. This enables precise control of motor speed and direction. The motors control the mobility of the robot by driving the wheels and also operate agricultural mechanisms such as the plough or drill for soil preparation.

Task execution is carried out through dedicated mechanical systems driven by motors and actuators. The digging mechanism creates furrows in the soil, preparing it for planting. The seed sowing mechanism stores seeds in a hopper and releases them through a rotating disc or timed chute at predetermined intervals after furrow creation.

A trailing attachment covers the seeds with soil. Additionally, fertilizer and water dripping mechanisms dispense the required nutrients and water using pumps and nozzles under the control of the microcontroller. Through this structured methodology, the Agribot performs agricultural tasks efficiently, accurately, and in an automated manner.

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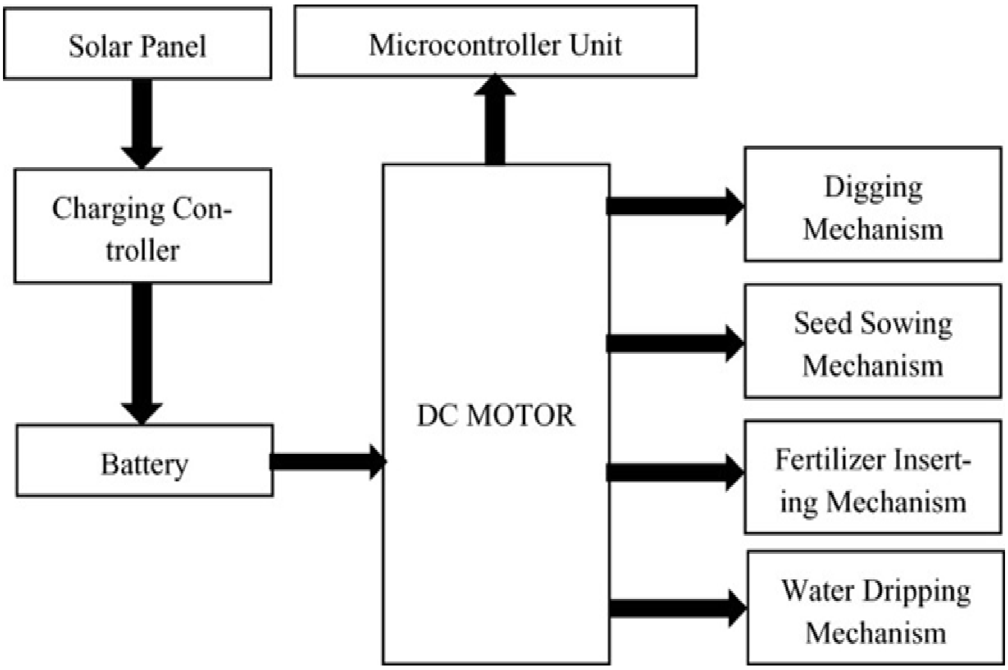



**WORKING**

The working of the Agribot is based on efficient power management, wireless control, and coordinated actuation of motors and mechanisms. The power system operates independently to keep the robot functional. A solar panel harness energy from sunlight and converts it into DC electrical power.

This power is regulated by a charging controller, which controls the voltage and current supplied to the battery, thereby preventing overcharging and increasing battery life. The battery stores the electrical energy and provides high-current power to the DC motors while supplying regulated low-voltage power to the microcontroller unit through a voltage regulator.

Remote operation is achieved using a Wi-Fi remote control system. The user interacts with the robot through a mobile application or web interface connected to the same Wi- Fi network. Commands such as movement, digging, seed sowing, watering, or spraying are sent wirelessly. These commands are received by a Wi-Fi module such as ESP8266 or ESP32 and forwarded to the microcontroller unit, which serves as the control unit of the system. The microcontroller processes the received digital commands using its programmed firmware and generates appropriate low-power control signals.

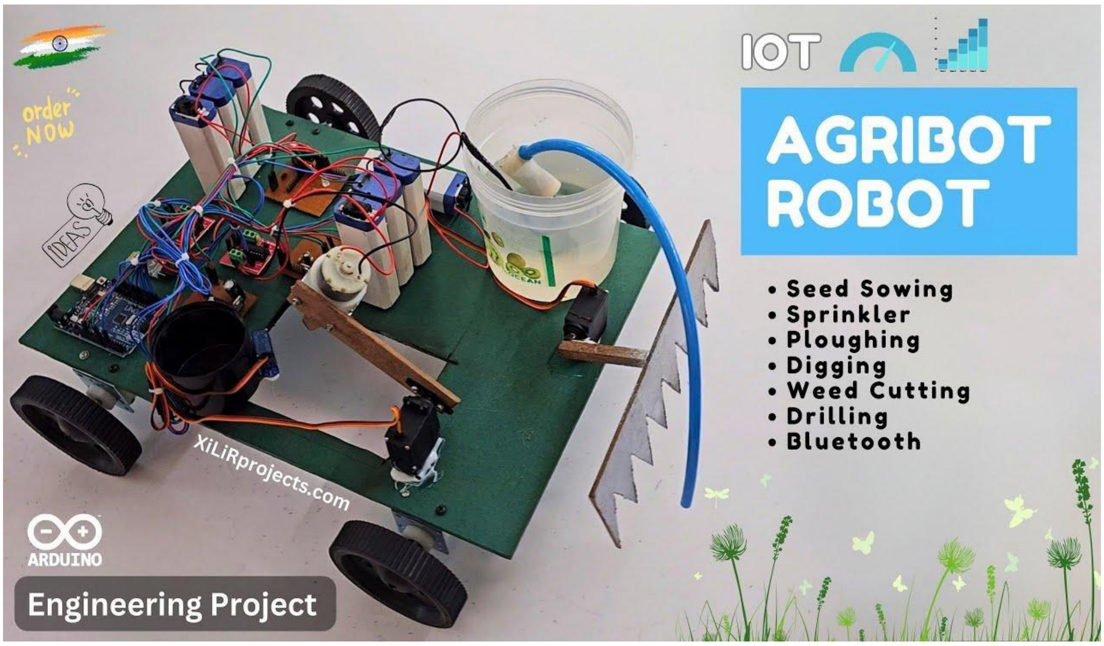
The control signals produced are forwarded to the motor driver circuit, which acts as the central power unit of the system. The motor driver, typically an H-bridge configuration
such as L293D or L298N, receives low-power signals from the microcontroller and high- power input from the battery. It controls the ON/OFF state, direction, and speed of the DC motors by reversing motor polarity. This arrangement allows the motors to rotate in clockwise or counter-clockwise directions as required.

The DC motor block powers both the robot’s movement and on-field agricultural mechanisms. For movement, the wheel motors are activated for forward, backward, left, or right motion. Forward and backward motion occurs when both motors rotate in the same direction, while turning is achieved using differential drive by changing the speed or direction of one wheel relative to the other. When a digging command is received, the microcontroller activates a dedicated DC motor connected to the plough, tiller, or drill mechanism to prepare the soil.

After digging, the seed sowing mechanism is activated, where a DC motor or servo motor releases seeds from the hopper at programmed intervals. For fertilizer insertion and water dripping operations, the microcontroller activates a relay that powers a DC pump or solenoid valve. The pump draws water or fertilizer from the reservoir and dispenses it through a nozzle onto the field.

Through this coordinated interaction between power management, Wi-Fi communication, microcontroller logic, motor driver circuitry, and mechanical mechanisms, the Agribot efficiently performs automated agricultural operations.

## RESULTS




The solar-powered multipurpose Agribot successfully performed all intended agricultural tasks, including seed sowing, watering, weed cutting, and pesticide/fertilizer spraying. The onboard sensors soil moisture level, ambient temperature conditions, and humidity accurately collected real-time field data, which was transmitted to a mobile/web application through IoT connectivity.

Farmers were able to monitor field conditions remotely and control the robot's operations efficiently. The use of solar panels provided continuous, clean energy, reducing dependency on external power sources. Testing showed a significant reduction in manual labor, improved accuracy in resource usage, and consistent operation even in remote fields. Overall, the Agribot demonstrated improved field management, reduced water and fertilizer wastage, and increased operational efficiency.

## CONCLUSION

The solar-powered Agribot proved to be an effective solution for modern, sustainable farming. By combining IoT technology with renewable energy sources, the robot automated essential agricultural tasks while reducing human effort and operational costs. Its sensor-based decision-making improved precision in watering, spraying, and monitoring crop conditions, helping farmers optimize resources and boost productivity. The project shows that affordable eco-friendly agricultural automation is possible and can significantly benefit farmers, especially in rural areas. The Agribot stands as a reliable, energy-efficient tool that supports smart farming practices and contributes to long-term sustainability in agriculture.

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