

# Design of Automated Multi-Functional Compact Equipment for Farmers

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**Abstract:** The project titled “Design of Automated Multi-Functional Compact Equipment for Farmers” aims to develop an energy-efficient and eco-friendly agricultural system for mechanized soil preparation and crop harvesting. Traditional soil loosening and crop cutting practices rely heavily on manual labor, fossil-fuel-powered machinery, or separate single-purpose implements, leading to high operational costs, operator fatigue, and carbon emissions to resolve these challenges, this project presents a solar-powered multi-functional compact unit integrated with an electric vehicle/tractor chassis.

A solar photovoltaic (PV) array charges a rechargeable battery pack that powers high-torque DC motors for a rotary soil loosening mechanism and a high-speed cutting unit. An Arduino microcontroller coordinates module activation, depth and height control via linear actuators, and real-time current monitoring for jam protection. By combining primary soil preparation and harvesting capabilities into a single renewable-powered platform, the system reduces manual labor, eliminates fossil fuel dependency, and promotes sustainable precision agriculture for small and marginal farms.

**Keywords:** Battery, DC Motor, Arduino, Filter, LCD, Joystick.

## I. INTRODUCTION

Soil loosening (tillage/aeration) and crop harvesting are two of the most labor-intensive and energy-demanding phases of agricultural production. Soil preparation requires breaking hard crusts to promote root aeration, moisture retention, and weed suppression, while timely harvesting ensures minimal crop shattering and yield loss. In developing agricultural sectors, smallholder farmers often lack access to affordable mechanization, relying on hand tools or hiring bulky, expensive diesel tractors that cause excessive soil compaction and environmental pollution. Integrating renewable energy with multi-functional farm machinery presents a sustainable path toward modernizing small-scale farm operations.

The proposed system employs solar photovoltaic (PV) panels to harness clean electrical energy, storing it in an onboard battery to drive both a soil loosening assembly and a crop cutting assembly. The soil loosening module uses adjustable rotary tines driven by a high-torque geared motor to break topsoil evenly, while the cutting unit employs high-speed circular blades or a reciprocating cutter bar to reap crops at a calibrated cutting height.

Managed by an Arduino microcontroller and equipped with motor overload sensing, this dual-purpose compact attachment minimizes operational time, lowers labor costs, and provides a sustainable alternative to conventional fuel-based farm equipment.

## II. PROBLEM STATEMENT

Conventional soil loosening and crop harvesting methods present substantial operational and economic bottlenecks for small and medium-scale farmers: High Labor Dependency and Fatigue: Manual weeding, digging, and sickle harvesting require intensive human labor, causing musculoskeletal fatigue and severe scheduling delays during peak seasonal windows.



**Fossil Fuel Costs and Emissions:** Conventional tractor-mounted tillers and combine harvesters consume expensive diesel fuel, generating significant greenhouse gas emissions and elevating the cost of cultivation. Lack of Compact, Affordable Mechanization: Commercial tractors and harvesters are bulky, difficult to maneuver in small, fragmented landholdings, and financially out of reach for marginal farmers.

**Mechanical Damage and Stalling:** Compact electric tools often risk motor burnout or gear stripping when ground-engaging tools strike stones, roots, or dense weed mats without active overload protection. To overcome these issues, there is an urgent need for an affordable, solar-assisted, multi-functional machine capable of performing both soil loosening and crop cutting with integrated automated protection and precision control.

### III. OBJECTIVES

1. To design and develop a compact agricultural machine capable of performing soil loosening and crop cutting.
2. To develop an efficient motor-driven mechanism for loosening the soil and cutting crops
3. To integrate both agricultural operations into a single machine to reduce the need for separate equipment.
4. To implement a suitable control system for operating the machine safely and efficiently.
5. To reduce manual labour, operational time, and the physical effort required for farming activities.
6. To develop a cost-effective and energy-efficient agricultural solution suitable for small-scale farmers.
7. To improve the efficiency of soil preparation and crop harvesting through agricultural mechanization.

### IV. SYSTEM DESCRIPTION

A. Power Supply System: Provides the required electrical energy to operate the motors and control circuits. A suitable battery can be used as the power source.

B. Motor Control System: Controls the operation of the motors used for soil loosening, crop cutting, and machine movement.

C. Soil Loosening System: Consists of a motor-driven rotating mechanism fitted with suitable blades or tines. This mechanism penetrates and loosens the soil to improve soil preparation.

D. Crop Cutting System: Consists of a cutting blade or cutter mechanism driven by a suitable motor. It is designed to cut crops during harvesting operations.

E. Machine Movement System: Uses wheels and a suitable drive mechanism to move the machine across the agricultural field.

F. Main Controller System: A suitable controller, such as an Arduino, can be used to control the motors and coordinate the operations.

G. User Control System: Includes switches or a suitable control interface to select and operate the soil loosening and crop cutting functions.

H. Frame and Integration System: A strong metal frame supports the motors, blades, battery, control unit, and other components. It integrates the different modules into a single compact machine.

### V. WORKING

The proposed machine operates using an electrical power supply that provides energy to the motors and control system. The operator selects the required agricultural operation using the control switches.

#### **Soil Loosening Operation:**

When the soil loosening function is activated, electrical power is supplied to the corresponding motor. The motor rotates the attached blades or tines, which penetrate and loosen the soil as the machine moves forward. This helps prepare the soil for further agricultural activities.



### **Crop Cutting Operation:**

When the crop cutting function is selected, power is supplied to the crop cutting motor. The motor drives the cutting mechanism, which cuts the crops as the machine moves through the field. The cutting mechanism must be designed according to the type and height of the crops.

### **Control and Movement:**

The control system manages the selected operation, while the movement mechanism allows the machine to travel across the field. The operator can stop or change the operation using the control switches.

## **VI. EXPECTED RESULTS**

The proposed system is expected to perform crop cutting and soil loosening efficiently using solar-powered electrical energy. The system aims to provide effective soil loosening and effective crop cutting, reducing manual effort, time, and labor costs. This mechanism is expected to improve agricultural productivity and support sustainable farming practices. The performance of the prototype, including soil loosening, crop cutting, battery voltage, and operating time, will be evaluated after testing.

## **VII. CONCLUSION**

The proposed Automated Multi-Functional Compact Equipment for Farmers provides a practical approach to improving agricultural efficiency by integrating soil loosening and crop cutting into a single machine.

The system uses suitable motors, mechanical attachments, an electrical power supply, and a control mechanism to perform the two operations.

By combining these functions, the machine aims to reduce manual labour, save operational time, and minimize the need for separate agricultural equipment. Its compact design can make it suitable for small-scale farming applications.

The project can be further improved by incorporating solar charging, automatic operation, obstacle detection, adjustable soil loosening depth, and improved crop cutting mechanisms. Overall, the proposed system aims to support cost-effective, efficient, and modern agricultural practices.

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