International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 15 Issue 02 , February - 2026

Design and Implementation of a Handheld Crop Cutter Powered by a Multipurpose Solar Photovoltaic for Enhanced Agriculture

Gebrihanes Sahle Weldengus, Haftu Mesele Mulaw, Selemon Gufi Aleme, Haftamu Haylay Gebrejewergs
[1]Department of Electrical Engineering, Mekelle Institute of Technology – Mekelle University

Abstract - Smallholder farmers in Ethiopia predominantly rely on traditional manual tools such as sickles for crop harvesting, a method characterized by low efficiency, high labor intensity, and vulnerability to time-sensitive risks including unseasonal rainfall and pest infestations. To address these challenges, this study presents the design and implementation of a solar-powered hand-held crop cutter integrated with a multipurpose photovoltaic (PV) system. The proposed system not only mechanizes the harvesting process but also provides auxiliary energy services, including LED lighting and mobile phone charging, thereby addressing rural energy limitations where grid electricity is unavailable.

The developed prototype consists of three load subsystems: (1) the primary crop-cutting unit, (2) solar lighting, and (3) a solar charging outlet. Power is supplied through a portable solar PV system with battery storage to ensure reliable operation. The system was successfully tested under practical conditions, demonstrating its capability to reap hay, illuminate two lamps, and charge a smartphone simultaneously. Performance evaluation indicated effective operation across all load subsystems, though cutting efficiency was reduced in thick hay due to mechanical limitations associated with the prototype assembly.

Overall, the solar-powered hand-held crop cutter demonstrates a cost-effective, environmentally sustainable, and locally adaptable solution for enhancing smallholder agricultural productivity while simultaneously mitigating rural electricity constraints. The system represents a scalable approach toward integrating renewable energy technologies into agricultural mechanization in developing regions, thereby contributing to efforts aimed at addressing global climate change.

Keywords:
Solar photovoltaic (PV) system; Hand-held crop cutter; Agricultural mechanization; Renewable energy; Rural electrification; Smallholder farming.

1. INTRODUCTION

1.1 Background

The economic trajectory of developing nations is intrinsically linked to the modernization of the agricultural sector. In countries where agriculture serves as the primary livelihood for the majority of the population, the transition from traditional subsistence methods to technologically advanced practices is essential for poverty reduction and food security [1]. Despite the global evolution of farming, many regions continue to rely on ancestral tools and methods that have remained largely unchanged for centuries.

In the Ethiopian context, crop harvesting, the critical final stage before threshing, remains a labor-intensive bottleneck. Manual harvesting using traditional sickles is not only physically grueling and time-consuming but also poses a significant risk to crop yield due to the narrow window of optimal maturity [2][3][4]. Delays in harvesting, often caused by labor shortages, expose matured crops to unseasonal rainfall, pest infestations, and grain shedding, leading to substantial post-harvest losses . While large-scale mechanized harvesters offer high efficiency, their prohibitive costs and unsuitability for fragmented, small-scale terrains make them inaccessible to the average Ethiopian smallholder.

Parallel to these agricultural challenges is the critical issue of rural energy poverty. Ethiopia possesses immense, yet largely untapped, renewable energy potential, particularly in solar irradiance, which averages roughly 5.5 kWh/m²/day across the highlands. Despite this abundance, the national grid extension to remote farming clusters remains economically and topographically challenging.

The integration of Solar Photovoltaic (PV) technology presents a transformative opportunity to bridge the gap between agricultural mechanization and rural electrification. By utilizing Ethiopia's abundant solar resources, there is a clear pathway to develop "Agri-Energy" solutions, tools that provide both mechanical power for harvesting and decentralized electricity for essential needs like LED lighting and telecommunications. This dual-purpose approach not only enhances field capacity but also elevates the socio-economic standard of living in off-grid rural communities, fostering a more resilient and sustainable agricultural ecosystem.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 15 Issue 02 , February - 2026

1.2 Problem Statements

Smallholder farmers in Ethiopia are constrained by a heavy reliance on traditional manual harvesting tools, such as sickles, which are characterized by low field capacity and high physical labor demands. This technological stagnation leaves crops vulnerable to time-sensitive threats, including unseasonal rainfall and pest infestations, often resulting in significant post-harvest losses. Furthermore, existing mechanized alternatives, such as large-scale combine harvesters, remain economically and geographically inaccessible to the majority of rural smallholders.

Compounding these agricultural challenges is the absence of adequate energy infrastructure in rural villages. This energy deficiency leads to insufficient lighting and a lack of charging facilities, stifling social and economic advancement and limiting opportunities for development and growth. Consequently, there is a critical need for an affordable, localized, renewable energy-based harvesting solution that enhances agricultural productivity while simultaneously addressing rural energy deficits.

1.3 Objectives

1.3.1 General Objective

The primary aim of this project is to design, implement, and evaluate a solar-powered handheld crop cutter to improve harvesting efficiency and provide auxiliary renewable energy for smallholder farmers in Ethiopia.

1.3.2 Specific Objectives

The specific objectives of this initiative include:

- To select a high-efficiency DC motor with sufficient torque for cutting both soft-straw crops.
- To design a portable solar PV system and battery storage to provide reliable power for harvesting operations.
- To integrate auxiliary power outlets for LED lighting and mobile device charging to address rural energy needs.
- To evaluate the machine’s field capacity and cost-effectiveness compared to traditional manual harvesting.

1.4 Literature Reviews

In [5], design and development of mini paddy harvester was described. This machine is a walk-behind type harvester powered by 1.5 kW (2 HP), 3000 RPM petrol engine. It has two circular blades, gears, belt, tire etc. as its components. This acts as a gate for the farmers to transform to large, efficient and modern combiners. Even though it is easy and cost effective, it is still uneconomic to our farmers. It has also other drawbacks like high running cost, large size and unfriend to the environment.
In the journal [6], the performance of wheat and rice harvesting using handheld crop cutter machine for smallholding farmers was analyzed. Comparison between engine driven crop cutter machine and manual operation was evaluated in terms of time and cost. The results showed harvesting crops using the crop cutter machine is more efficient and effective than manually reaping crops. This machine reduces the time and man power required to harvest. It is also affordable to small-scale farmers. However, it is not cost effective due to fuel running cost, pollutes environment, and has noise that disturbs while working.

[7] Developed compact multi crop cutter powered by pollution free 1hp electric motor. It was designed and implemented practically for small-scale farmers. The components used to construct this machine are: electric motor, pulley, bearings, V-belt and flat belt, spur gear, shaft, scotch yoke mechanism, collecting mechanism and cutter blade. The electric motor was energized by electric supply to drive the blades and collecting mechanism via the belts and gears. Finally, they tested this cutter machine for harvesting wheat crop and it was observed that 1173Rs. per day per 0.4 hectare can be saved when crops cut by this machine compared to manually. Drawbacks of this machine are it cannot be used for lands far from grid and is somewhat complex and difficult to repair by the local farmers.

[8]Designed crop cutter machine to transform farmers from conventional method of harvesting crops to semi mechanized method. This machine comprises of four wheels, dc motor, blade cutter, battery, pulley, shaft, belt and Plummer block. The pulley and cutter are mounted on a single shaft driven by the motor which is powered by the battery. When the motor drives the shaft, it transfers the power to the pulley and then to the cutter. As the cutter rotates, it will cut the crop continuously. Despite this machine reduces cost, human effort and working time, it requires large battery capacity.

As shown in [9], the design and fabrication of harvesting machine was explained. The machine has two blades which cuts the crop and is targeted for small scale farms. Its source is a petrol engine of 3HP (2.2371 KW). The power from engine is provided to the cutter through pulley and gear box arrangements. But this machine is not cost effective, difficult to maintain by the farmers, has high running cost and is not friendly to the environment.

In [10], an environmentally friendly renewable source of energy that is solar panel and designed a portable solar powered grass cutter machine to cut lawn in schools, colleges and gardens was proposed. The main components used in this project are: solar panel, battery, 12V DC motor, cutting blades, spur gears, bearings, sheet metals and metal rods. It was designed to use 10W, 18V

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 15 Issue 02 , February - 2026

solar panel to drive the DC motor which rotates the cutter blades via gear with gear ratio 2.5. Nonetheless, this project was not implemented practically, requires maintenance periodically due to the brush contact in the DC motor.

[11] Presented design of solar powered walking crop cutter. It contains solar panel, DC motor, battery, cutting blades and other mechanical supports. The motor is powered from the battery and by turn it rotates the blades to cut the crop. They selected DC motor and solar panel with rating of 18W. The machine is driven by man power. It uses clean and reliable energy source, and aborts direct man power for cutting. But it has drawbacks like can vibrate when driven by man power, it needs high manufacturing technology, difficult to maintain by farmers, and large hence not easy to transport.

[12] Proposed a Solar energy-based crop cutter was compared and contrasted with the fuel powered cutter machine in this journal. They clarified:

- Fuel energy is non-renewable energy source while solar energy is freely available in nature.
- It is advisable to use handheld cutting machines rather than mechanized machines due to the small-scale farming.
- The fuel powered is environment pollutant, but solar is free of any pollution.
- The solar powered crop cutter is having low maintenance cost, operating cost and light in weight.

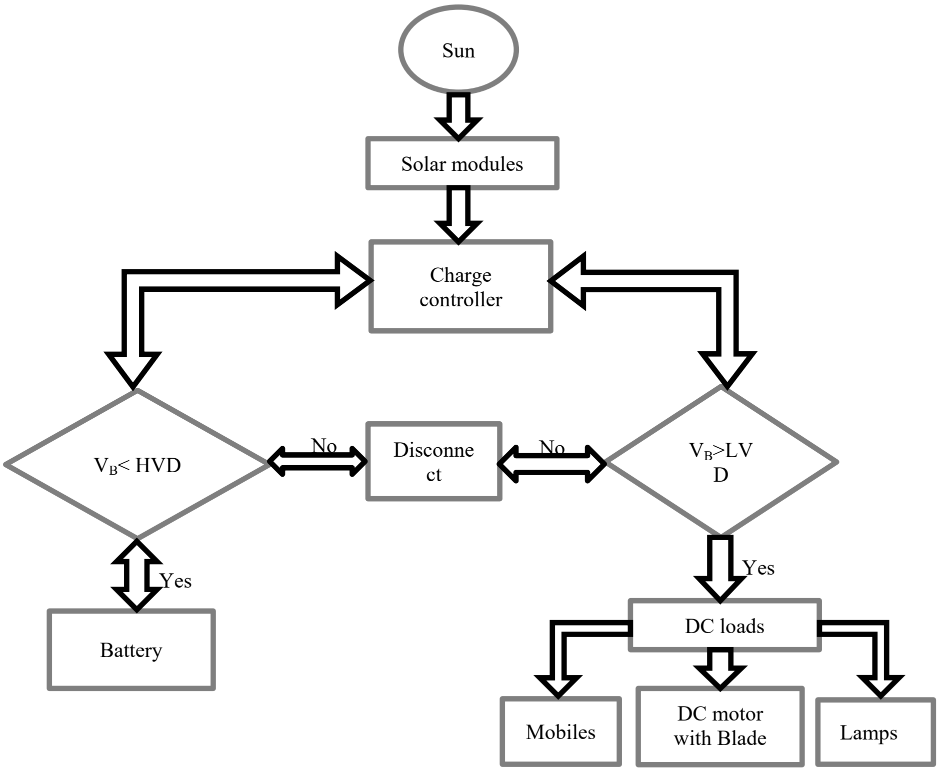
Having read the above literatures and point out their strengths and weaknesses, we encouraged to do this project by taking the positive contributions for the literature and eliminate some of their drawbacks. Our project uses a machine that has small size and less weight so that it can be carried, and solar panel that has almost zero running cost and is environmental friendly. The peculiar advantage of this project is, it has a multi-purpose solar PV system which is useful even during in the non-harvesting time for lighting and charging mobiles, radios and so on.

2. METHODOLOGY

We use the following steps to design, implement and/or assemble handheld crop cutter machine powered by multipurpose solar PV system.

- Conduct a thorough analysis of the requirements for a solar-powered hand-held crop cutter, considering cutting efficiency, power needs, ergonomics, and user-friendliness.
- Research existing crop cutting mechanisms and solar PV systems to gather insights and identify design considerations.
- Develop algorithm/flowchart of the whole system.
- Select appropriate mechanical components for the crop cutter, taking into account the availability of materials and feasibility for testing purposes.
- Select suitable type of electrical motor considering the type of energy supply and characteristics of the load.
- Design a solar PV system that can efficiently power the crop cutter, provide lighting, and charge electrical devices, considering factors such as solar panel selection, battery capacity, and charging mechanisms.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 15 Issue 02 , February - 2026



2.1 Flowchart

Figure 1 Flowchart of the system

2.2 Operation of the System

This project utilizes the plentiful and one of the sustainable energy resources that is sun energy as a source of electrical energy. The sun energy is converted to electrical energy using a photovoltaic system that is when the sun radiation strikes the **P** and **N** types of the cell, and a potential difference is induced across the anode and cathode terminals which causes current to flow if the circuit is closed.

The induced voltage and current are increased by connecting the cells in series and in parallel respectively, which constitutes a solar module or panel. This solar module is connected to a solar battery via a charge controller. The solar battery stores the electrical energy in the form of chemical energy and the charge controller controls the battery from over charging and deep discharging.

When needed, this stored energy is converted to electrical energy and this is supplied to a DC motor, mobile charger and DC lamps. Thus, the mobiles will get charging via the charger and lamps will be turned on. And when the DC motor is energized, a current will flow through its armature winding. This current will then interact with the magnetic field of the stator. Due to the interaction of the armature current and the magnetic field, a torque will be produced which causes the rotor to undergo a rotational motion. This in turn rotates a blade or crop cutter that is attached to it.

Finally, when the rotating blade is made close to straws (crop stems), the crops will get cut. The reaped crop will be gathered and placed to one side by a combined with the help of human power.

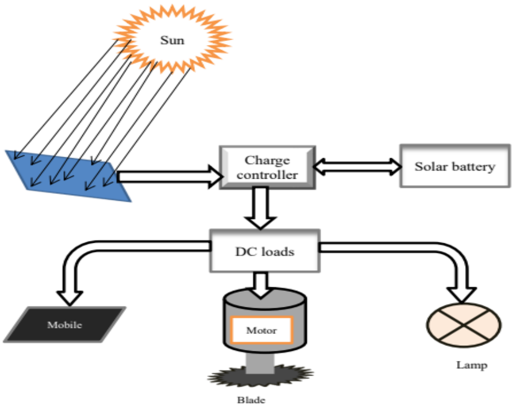


Figure 2: Block diagram of the system

2.3 Materials used

The components used to implement this project are solar panel, charge controller, solar battery, electric motor, combiner, blade, mechanical connectors, light bulbs and IC regulator. These materials are designed to their required size/ rating. They are also assembled.

3. Design and Implementationsss

3.1. Component design and selection

The system has three types of loads viz. lamps, straw of crops and mobiles.

1. Lighting: the system is used for lighting in rural areas. We select DC lamps since the electrical energy source is DC. Two lamps with rating of 5W are enough to illuminate at most two houses in villages.
2. Charging mobiles: To charge the mobiles IC regulator, USB port and charger cables are used. Since the USB and the cables are rated to 5V, an IC regulator with output of 5V will be used. Thus, the regulator is powered from the charge controller's DC terminal and fixes the output voltage to 5V in order to match to the voltage rating of the mobile. And the USB port is used to have a safe interconnection between the regulator and the mobile to eliminate electric shock and simplify the connection and isolation of mobile from regulator. More mobiles can be charged at a time by using multiple cables in one USB.
3. Cutting crops: The crops will be cut by a rotating blade driven by a motor. Previously this was tested using a DC motor of rating 48W and good result except its some drawbacks. Considering efficiency, size and weight a DC motor of 12V and 6A (53W) is selected.

3.1.1 Battery design and selection

The solar battery will be sized and selected by the largest and less used electrical load motor. It is used only during the harvesting period, hence at any other time to be used diversely by the other loads. The size of the battery depends on the number of autonomy days in which it delivers electric power supply without input sun energy, and the total electric energy per day used by the appliances. Here, the motor will run for one days and 8 hours per day without sun energy. Hence, Days of Autonomy (DOA) is 2. Depth of Discharge (DoD) is 20% [2]

Battery capacity = $\frac{P \times OH}{nominial\ battery\ voltage \times (1-DoD)} \times Do$ ---(2.1)

Where,

P is power rating of the motor

OH is number of operating hours per day

Since the voltage rating of the motor is 12V, a solar battery that has 12V nominal voltage should be selected.

Battery capacity = $\frac{53W \times 8\ hrs/dAY}{12V \times (1-0.2)} \times 2day$ = 89 Ah

Thus, a 12V, 89Ah solar battery will be used. However, two batteries with 45Ah can be used alternatively.

3.1.2 **Charge controller design:** voltage rating of charge controller is designed based on the working voltage range of the load. A charge controller with 12V nominal voltage is required as the motor and lamp ratings are 12V.

Charge controller current = $\frac{\text{total array wattage}}{\text{battery nominal voltage}}$ …………………………………………….(2.2)

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 15 Issue 02 , February - 2026

Charge controller current = $\frac{72W}{12V}$ = 6A

For safety purpose 1.25 safety factor is applied.

Thus, charge controller current = 1.25×6A = 7.5A

3.1.3 Design of PV array and selection of PV module

As the loads operate at different times that means mobiles are charged in the day time, lamps are active at night and the motor is to run during the harvesting time only, and the largest electric power is absorbed by the motor. As a result, for economic purpose, the PV array is designed by the motor rating. Therefore, a PV array system that has a capacity to supply 53W (motor rating) is required. The number of modules needed to connect in series-parallel to form the required array is calculated as follow.

PV panel current = $\frac{system\ capacity}{nominial\ voltage}$ ---(2.3)

$= \frac{53}{12} = 4.4\text{A}$

Number of parallel modules = $\frac{\text{Total PV array current}}{\text{module current}}$

From data sheet a module with 72W, 12V and 6A is used[4]

$= \frac{4.4A}{6A} = 0.736 = 1$ module

One module is enough to from the specification taken.

Number of series modules = $\frac{system\ voltage}{nominial\ voltage} = \frac{12V}{12V} = 1$ module

Therefore, one module(1×1) is enough to supply the system in parallel.

3.1.4 Design of interconnection wire

Cable connection is designed based on the maximum current of the system. This is obtained by the formula given below.

$I_t \geq = \frac{\text{In}}{\text{CaCi}}$ [5]

Where, I_t – current carrying capacity of the cable

I_n – nominal current of protective device = 7.5A (charge controller rating current)

C_a – correction factor for ambient temperature, 1 for 30°C

C_i – application factor for thermal insulation,

$I_t \geq 7.5$A

It = 10A, from EBCS10 a cable with 2.5mm2 cross section is to be selected

3.1.5 Design of blade cutter: the blade is designed with the following specifications so that it will be suitable for reaping crops quickly as much as possible [6]:

- Diameter of blade – 415mm
- Number of teeth – 120

3.2. Implementation of the System

3.2.1 Prototype Development:

- Develop initial designs, including detailed schematics and technical drawings, for the crop cutter and solar PV system integration.
- Procure the selected mechanical components and assemble them to create a functional prototype of the solar-powered hand-held crop cutter.
- Integrate the designed solar PV system with the crop cutter, ensuring proper electrical connections and power transmission.
- Conduct initial testing of the prototype to evaluate its performance, cutting efficiency, and power generation capabilities.

Gather feedback from farmers and stakeholders regarding usability, ergonomics, and any required modifications.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 15 Issue 02 , February - 2026

3.2.2 Schematic diagram

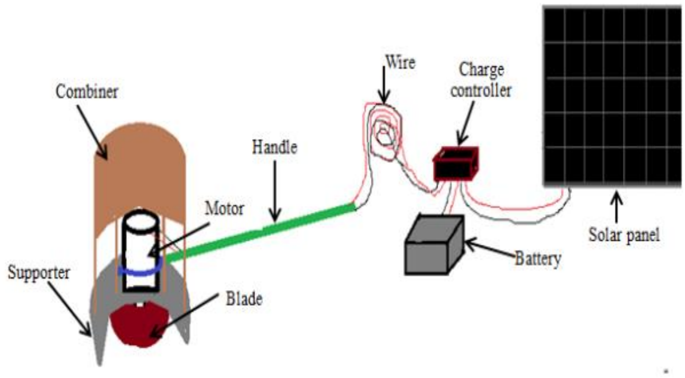


Figure 3: Schematic diagram of the system

The components used in this thesis are not the specifically needed materials instead was used those which are easily available. Their preparation to assembly is also explained as follows.

3.2.3 Selected DC motor and its Testing

A DC motor with rating of 24V voltage and 2A current as shown in figure 4 is available and used to drive the blade of the system. It is tested and works functionally but has high resistance that is around 300Ω.

Figure 4: DC motor

3.2.4 Preparation and Construction of the Mechanical Parts

The crop cutter machine has four main mechanical parts. These are:

1. Blade: is a disc with hallow at its centre and slotted teeth at its periphery. It should have optimum size and be designed correctly i.e. its teeth should be slotted at equal distances and skewed in anticlockwise. In our case we made the blade manually using hacksaw from abandoned metal and sharpened by a sharpener. It has 55 numbers of teeth and 17cm diameter. We bored at its centre with an electrical driller to fit with the motor shaft of the motor. At last, the motor shaft is tightly attached to the blade in order to rotate it so that the crops will be cut down.
2. Combiner: the crops cut by the blade should be laid to the land in a combined manner. And this done by a combiner. This prevents the crops from spreading away. Regardless of its mechanical design, we made it from light nonfunctional thrown corrugated iron manually using hacksaw.
3. Handle: is the controlling system of the machine using human power. This is made long enough so that the worker reaps while being stand up. This prevents the worker from getting pain on his/her backbone. This can be made from a light steel or wood. But, here it is made from a wood.
4. Supporter: the motor with the blade, combiner and handle needs a supporting means that hold them tightly and compactly

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 15 Issue 02 , February - 2026

together. Even though it needs optimum design regarding to its weight and size, we prepare it from a thrown metal and shaped with a hacksaw.

The interconnecting nodes of these components are bored by a driller. Their practical production can be seen in figure 5.

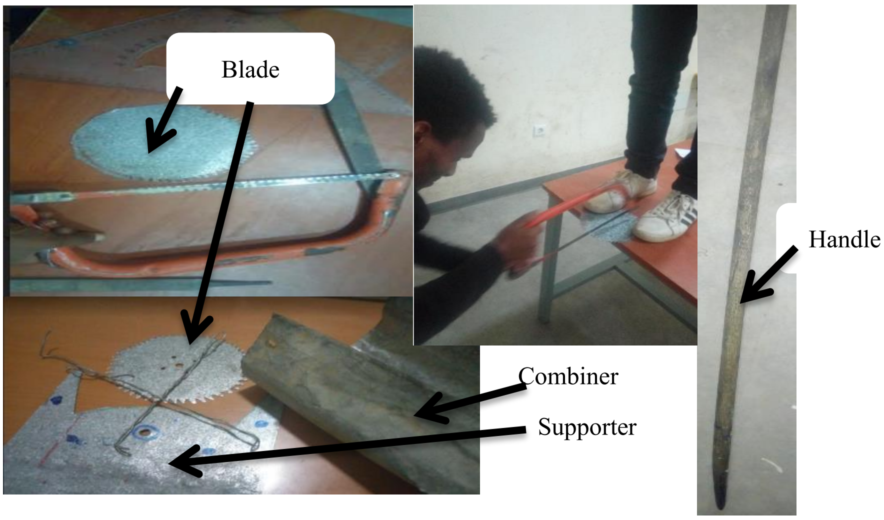


Figure 3. 1: Preparation of the mechanical parts

Figure 5:Preparation of materials

Finally, these mechanical components are integrated to each other with motor using nuts and interconnectors. The connectors and combined components are shown in figure 6.

Figure 6: Mechanical connectors and the interconnected components

It is powered by a solar PV system. Two solar modules of 17.4V and 3.05A are used to generate the electric power. This energy is stored in two solar batteries of 12V and 7.2Ah rating each and controlled by a charge controller rated 12/24V and 10A. These solar components are shown in figure 7.

Solar module Charge ontroller Solar
battery

Figure 7: Solar PV system components

To have a safe connection, first battery should be connected to charge controller, next load and then solar PV, and we should follow the reverse process in disconnecting. This is because if PV is connected first, it can draw large peak voltage that can cause damage to the load [6] .

The solar PV system is electrically connected to the cutting machine through electric wires having 2.5mm^2 cross-sections, and one way switch as it can be observed in figure 8. Hence, we control the flow of current feed to the motor using the switch.

Figure 8: Interconnected system of the crop cutter machine

The solar PV system is also used for lighting and charging mobiles. To illuminate houses, DC lamps are connected directly to the load terminal of the charge controller. For charging mobiles a 7805 IC regulator and USB port are used in which the regulator is powered from the charge controller's DC terminal and supplies 5V to the USB. These subsystems are illustrated in figure 9. Due to the lack of USB we connect the mobile directly to the regulator via charging cable.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 15 Issue 02 , February - 2026

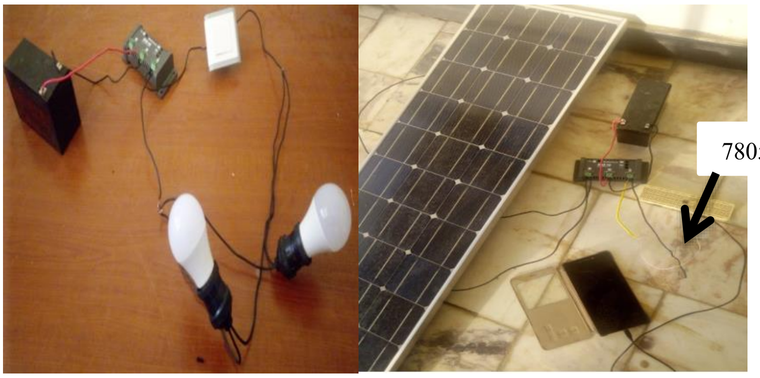


Figure 9: When the solar PV system is connected to lamps and mobile

When we need to charge more mobiles at a time, a multiple output cable can be used.

4. Results and Cost analysis

4.1 Results and discussions

In this paper a system called “handheld crop cutter machine powered by a multipurpose solar PV system for enhanced agriculture” is implemented practically. The system has three sub systems viz. crop cutter machine, solar charger and solar lighting, and all these use one solar PV system. The cutter machine reaps crops, the solar charger charges mobiles during daytime when there is sun and the solar lighting gives light for houses. All these are assembled and implemented practically, and the results demonstrate the successful development and implementation of a practical and efficient solution for crop harvesting, lighting and charging. The results we obtained are explained as follows.

4.1.1 Result of crop cutter machine

The assembled reaper/cutter machine was tested in MIT for cutting long and thick hay as shown in figure 10.

Figure 10: Result of the reaping machine

It was cutting the hay little by little. The reasons are:

- The motor was not operating at its rated power (48W) instead at about 12W as the motor is aged and has high resistance
- The cutting blade is not sharpened as required since it was made manually by our hands.
- The blade was vibrating as it was not connected tightly to the shaft by bearing instead tied by a rope.
- Teeth of the blade are not uniform and their gap is not equal as they are made manually by hands.
- The mechanical designs of the combiner and supporter had some effect on the result.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 15 Issue 02 , February - 2026

- The grass used for testing is stronger than what we want to cut i.e. the crops like wheat, barley.

The foregoing result and discussion indicates if a new updated more efficient motor and effectively manufactured mechanical components for example well slotted and sharpened blade are used, and if these are also connected tightly, the machine will reap crops affectively.

4.1.2 Result of solar lighting

The battery was charged up to its rating using solar module. When the battery was connected to the lamps, the lamps give a light with a good brightness. It was used in a library room for studying when there was no supply of electricity from grid and fuel generator. It was enough to illuminate two lamps as required. This is given in figure 11.

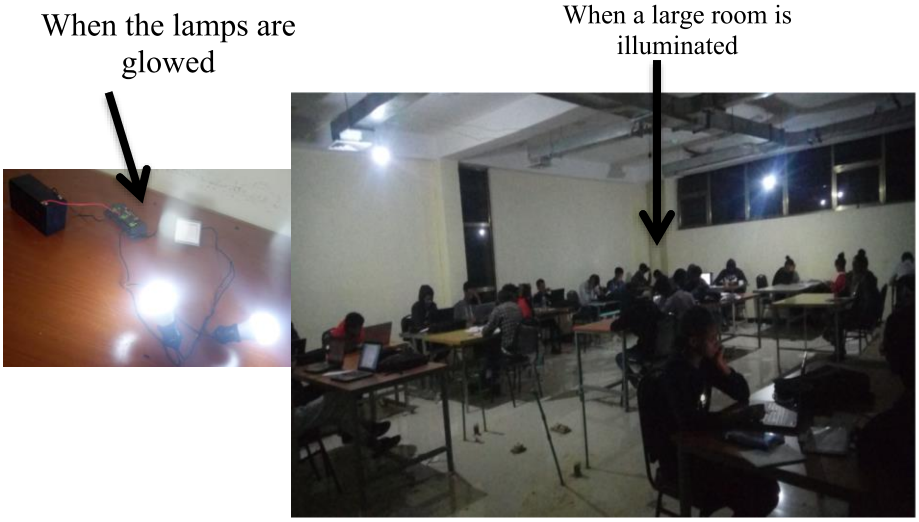


Figure 11: When the system glows the lamps and illuminates large room

From this one lamp is enough to illuminate one room in a rural house. As a result, these two lamps are to be used to illuminate two houses.

4.1.3 Result of charging mobile from the solar PV system

A mobile was connected directly to the DC terminal of the charge controller via 7805 IC voltage regulator and charging cable. The IC regulated the 12V voltage from the battery to 5V and the mobile was able to charge as given in figure 12.

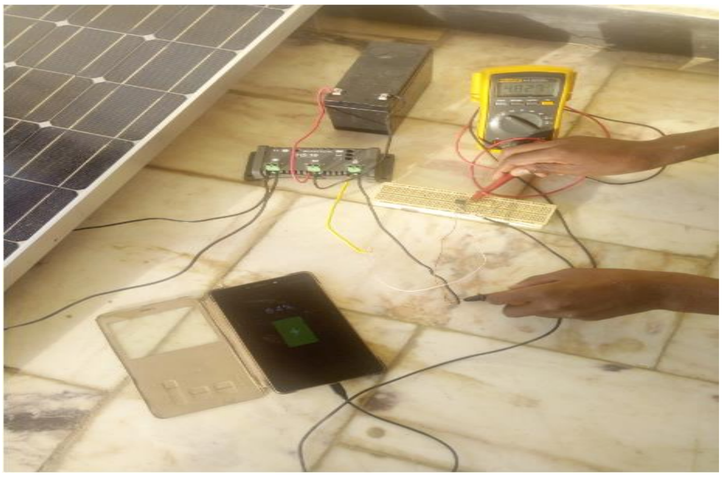


Figure 12: When a mobile charges from the system

4. CONCLUSION

This work successfully developed a multifunctional solar-powered system designed to bridge the gap between agricultural mechanization and rural energy access. The prototype effectively integrates a handheld crop-cutting unit with auxiliary outputs for

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 15 Issue 02 , February - 2026

LED lighting and mobile device charging, powered by a portable photovoltaic system. Experimental testing validated the system's capacity to perform these functions simultaneously under field conditions, proving that renewable energy can be a viable, cost-effective, and environmentally sustainable alternative to traditional manual labor. While initial mechanical challenges such as vibration and motor torque were noted during heavy-duty reaping, the core objectives of design, integration, and functionality were achieved.

In summary, this project provides a scalable solution to the labor inefficiencies and energy shortages faced by smallholder farmers in Ethiopia. By reducing the physical burden of harvesting and providing essential electricity for off-grid communities, the system directly contributes to improved agricultural productivity and rural socio-economic livelihoods. This work underscores the transformative potential of integrating decentralized solar energy into localized agricultural tools, offering a sustainable pathway toward modernized farming and enhanced energy security in developing regions.

5. FUTURE WORK

To further improve the impact and efficiency of the proposed system, future research and development will focus on the following areas:

- Technical Scalability: Research will explore the use of more efficient lithium-ion battery storage and lightweight PV panels to increase the system's portability and endurance during peak harvesting seasons.
- Mechanical Optimization: To address the limitations found in the prototype, future designs will ssutilize higher-torque DC motors and advanced vibration-damping materials to improve user ergonomics and cutting precision.
- Integrated Multi-Process Design: Future iterations aim to transform the device into a "comprehensive sustainable farming suite" by incorporating modular attachments for tilling and threshing, creating a single unit for the entire crop cycle.

References

[1] G. Gebrerufael, "Smallholder Subsistence Agriculture: Why Ethiopia is Still Here?," vol. 1, 3 2015.

[2] "https://byjus.com/biology/crop-production/," [Online]. [Accessed Monday June 2021].

[3] C. Karthikeyan, D. Veeraragavathatham, S.F Ayisha, "Traditional tools in agricultural practices," 25 February 2008.

[4] E. MULUGETA, M. SAMUEL, A. ASSEFA, M. TAMIRAT, B. MIHRET, "Motorized Reaper Machine," 25 05 2009 .

[5] C. Aravind, V. Shivashankar, R. Vikas, "Design & Development of Mini Paddy Harvester," *IJSRD - International Journal for Scientific Research & Development,* vol. 03, 05 2015.

[6] U. Kumar, N. Chandra, J.S. Mishra, B.P. Bhatt, "Performance and Evaluation of Hand Held Crop Cutter Used in Wheat and Rice Harvesting," *International Journal of Agriculture Sciences,* vol. 8, pp. pp.-1364-1365, 08 March 2016.

[7] S.G. Vilas], P.G. Pravin, K.D. Yogesh, S.J. Anil, A.L. Pooja, K.M. Praveen, "Design, Development and fabrication of Multi Crop Cutter Powered by Electric Motor," *International Journal of Application or Innovation in Engineering & Management (IJAIEM),* vol. 6, p. ISSN 2319 – 4847, 05 May 2017.

[8] P. Prajakt, B. Pratik, L. Samruddha, J. Bhushan, T. Ankit, "Design of Crop Cutter Machine," vol. 3, 03 2017.

[9] B.M. Amar, T.S. Pravin, A.C. Akshay, N.B. Akash, D.S. Dhananjay, R.G.Kapil, "DESIGN AND FABRICATION OF HARVESTING MACHINE," vol. 05, 01 January 2018.

[10] A.R. Deepak, K. Kiran, E Daneesh, K. Rabin, C.N. Punith , "Design and Fabrication of Solar Grass Cutter," *International Journal of Latest Engineering Research and Applications (IJLERA),* vol. 03, 05 May 2018.

[11] H.T. Sreenivas, M. Chaitra, "Conceptual Design and Development of Portable Solar Multi Crop Cutter," August 2020.

[12] B. Mohnish, C. Pratiksha, R. Dipak, H. Prajkta, T. Nikita, "Solar Energy Based Crop Cutter," vol. 8, 05 May 2020.

[13] Charwak, K. Mukul, K. Saurabh, K. Manish, "Desine and fabrication of crop cutting," 06 June 2019.