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DEVELOPMENT AND EXPERIMENTAL EVALUATION OF A SOLAR–POWERED LAWN MOWER USING LOCALLY SOURCED MATERIALS

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Abstract: This study addresses the urgent need for sustainable and eco–friendly alternatives to traditional gasoline–powered lawn mowers, which contribute significantly to noise and air pollution. It focuses on the design, fabrication, and performance evaluation of a solar–powered lawn mower tailored for residential lawn maintenance in tropical environments. The mower was structurally enhanced with an improved frame design and added caster wheels to increase maneuverability. A 12V DC motor, powered by a 45Ah battery and charged via a 60W solar panel, drove various interchangeable blade types. These blade designs—–straight, 2–sided, 3–sided, and 4–sided—–were tested across three commonly found grass species: Milk Weed, Kentucky Bluegrass, and SidaAcuta. Performance was assessed based on cutting time, efficiency, and speed, with the 2–sided blade demonstrating superior results across all grass types, achieving the highest efficiency of 87.9% and cutting speed of 0.558 m/min in Milk Weed conditions. The mower also performed consistently under more demanding conditions such as Kentucky Bluegrass and SidaAcuta, though performance declined with more complex blade geometries like the 4–sided configuration. Comparative analysis with prior literature confirmed the viability of the design and the critical role of blade geometry in enhancing energy efficiency and operational performance. The results validate the feasibility of low–cost, solar–powered mowing solutions using locally sourced materials, suitable for urban and semi–urban households. The study concludes with design recommendations for future enhancement, including adjustable blade height, autonomous control systems, and expanded solar power capacity.
Keywords: Solar mower, blade efficiency, lawn maintenance, renewable energy, environmental sustainability

INTRODUCTION

A lawn mower is a machine that is used to cut grass in a lawn. A lawn mower is a machine which employs a revolving blades to cut a lawn to an even height. The lawn mower which employs a blade that rotates about a vertical axis are known as rotary mowers while those which uses a blade assemble that rotates about a horizontal axis are known as cylinder or reel mowers (Dana, 2017). Grass cutting has historically been a labor-intensive task, particularly when performed with basic hand tools such as sickles, shears, or machetes. The need to reduce physical effort led to the development of early mechanical devices like reel mowers and hand-operated trimmers (Drake *et al.*, 1970). Despite offering some efficiency, these tools still relied heavily on human input. Over time, the invention of engine-powered lawn mowers revolutionized lawn care, beginning with Edwin Budding's 1830 mechanical mower prototype, which incorporated a cylinder blade and gear transmission system (Sivagurunathan *et al.*, 2017).

Throughout the 19th and 20th centuries, innovations focused on improving usability, speed, and power. Developments included chain-driven systems, steam-powered units, and later, gasoline-powered mowers that gained widespread use in both Europe and North America (Khurmi, 2005). By the mid-20th century, electric models and lightweight materials such as plastic were introduced to further simplify operation (Venkatesh *et al.*, 2015). Despite these improvements, fossil fuel dependency remains a major concern due to environmental degradation, noise, and cost.

The global shift toward renewable energy technologies present an opportunity to integrate solar energy into lawn maintenance equipment. Solar-powered mowers operate using photovoltaic (PV) panels to convert sunlight into electrical energy, which then drives a motorized cutting blade (Tanimola *et al.*, 2014). With average global solar irradiance estimated at over 5.68×10^{18} calories per minute, and Earth receiving just a fraction of it, the sun offers a virtually inexhaustible energy source.

Growing environmental consciousness and the rising cost of fossil fuels have intensified interest in clean energy alternatives. Solar-powered mowers provide a dual benefit: reducing operating costs and lowering carbon emissions. Moreover, they eliminate the risks associated with gasoline storage, spillage, and combustion engine noise. As industries shift toward more sustainable operations, the need for practical, efficient solar-powered devices becomes critical (Fernandez and Krishnasamy, 2018).

Moore *et al.* (1997) performed the measurement and analysis of a lawn mower in terms of its performance and noise level. Ahamed and Ziauddin (2011) developed a small scale electric lawn mower in addition, Namoco *et al.* (2013) developed a mechanical push lawn with double cylinder for blade spinning in order to increase the system's capacity and operational efficiency. Onuabuchi et al., (2024) developed and tested solar powered lawn mower with 12 V successfully. Deranda *et al.* (2018) developed a smart robot lawn mower which does not require boundary cable for its operation in order to reduce the cutting cycle time and operational cost. Selvanesan *et al.,* 2025 found that smart lawnmowers have the potential to be valuable tools for users seeking to save time and reduce the expenses associated with lawnmowing. Islam and Ali (2024) developed solar-powered lawnmower for use in residences and companies with lawns where tractor-driven mowers couldn't be used. The machine's field efficiency was 83.7%, which is a comparatively high Figureure. The machine's handle may be adjusted, making it simple for both men and women of different heights to use.

Dipin and Chandrasekhar (2014) studied solar powered vision based Robotic Lawn Mower. It showed the design of a microcontroller and sensor based robotic lawn mower mechanism. Ultrasonic sensors were used for avoiding obstacles and humidity sensor for checking humidity level in the lawn. Passive infrared sensor (PIR) was used to detect human interaction near the device in operation. Android smart phone was used for capturing images of the lawn as per requirement. This design is targeted as an alternate green option against the popular but environmentally hazardous gas powered lawn mower.

Satwik *et al.* (2015) designed and fabricated a lever operated solar lawn mower and contact stress analysis of spur gears. They tried to develop a height adjustable mechanism for the cutting blade. The mechanism involves a pair of spur gears of different face width and a lever which adjusts the rotor height such that the smaller spur gear slides on the face width of the larger spur gear. An Arduino board was used to control the speed of the rotor blade and obstacle detection. Solar panel receives sunlight and powers the battery which in turn runs the motor.

This study proposes the design, fabrication, and evaluation of a solar-powered lawn mower tailored for diverse grass conditions using different blade geometries. Specifically, the project designed lawn mower frame for improved maneuverability by integrating front caster wheels and enhancing ergonomic design. A 12V DC motor powered by a 45Ah battery—recharged using a 60W photovoltaic panel—served as the propulsion system. Four blade types (straight, 2-sided, 3-sided, and 4-sided) were fabricated from galvanized steel and tested on three common Nigerian grass types: Milk Weed, Kentucky Bluegrass, and SidaAcuta.

The research investigates the efficiency, cutting speed, and adaptability of each blade type on different terrains to identify the most effective configuration. It also assesses whether such a mower, constructed from locally available materials, can offer an affordable, environmentally friendly alternative to gasoline-powered counterparts. This approach provides insights into the practicality and scalability of solar-powered technology for lawn maintenance in resource-constrained settings.

MATERIALS AND METHODS

Machine Description

The solar-powered lawn mower consists of mechanical and electrical systems integrated to deliver sustainable grass-cutting performance. The frame is built from mild steel, offering durability and lightweight structure. A 12V DC motor rated at 3000 rpm serves as the drive system. The motor receives power from a 45Ah lithium-ion battery, which is recharged via a 60W solar panel optimized for direct sunlight conditions common in Nigeria.

To improve maneuverability, the rear-wheel drive was designed to include the addition of two front caster wheels. This enhancement allows for smoother steering and better stability, particularly on uneven ground. The handlebar was designed to be adjustable for ergonomic support and operator convenience. The isometric view of the machine is shown in Figure 1.

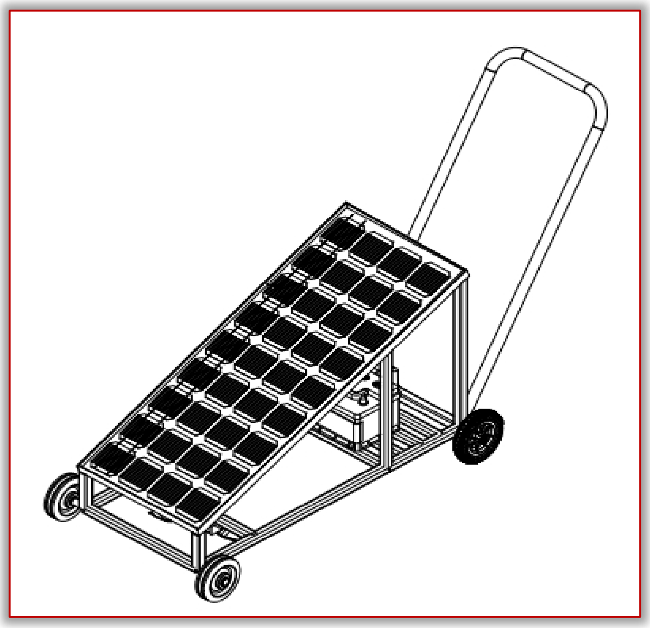

Figure 1: 3D Isometric view of the machine concept

Power System and Design Calculations

The blade was designed with the following dimensions:

Blade Length (L) = 190 mm = 0.19 m,

Blade Breadth (B) = 38 mm = 0.038 m, and

Blade Thickness (T) = 2 mm = 0.002 m.

The area of the blade was calculated as:

$$\text{Area} = \text{Width} \times \text{Length} = 0.038 \times 0.19 = 0.00722\ m^2$$

The volume of the blade = Area × Thickness = 0.00722 × 0.002 = 0.00001444 m^3

Using the density of mild steel (7850 kg/m^3), the blade mass was:

Mass = Volume × Density = 0.00001444 × 7850 = 0.1133 kg

The weight and torque on the blade were determined as follows:

Blade weight, W = Mass × g = 0.1133 × 9.81 = 1.111 N

Torque = Weight × Radius = 1.111 × 0.095 = 0.105 Nm

The angular velocity (ω) of the motor operating at 3000 rpm is given by:

$$\omega = \frac{2\pi N}{60} = \frac{2 \times \pi \times 3000}{60} = 314.16 \text{ rad/s}$$

The power developed by the blade was:

Power = Torque × ω = 0.105 × 314.16 = 33 W

This power value was then converted to horsepower:

Horsepower = 33 × 0.00134 = 0.044 HP

The design power was determined using Equation 1 (Igbokwe *et al.*, 2019): Design power =

$$\frac{I \times V}{\text{Powerfactor}}$$

where I = Current, V = 12V, and

Power factor = 0.8

Rearranging to solve for current:

$$I = \frac{\text{Designpower} \times \text{Powerfactor}}{V} = \frac{33 \times 0.8}{12} = 2.20 \text{ A}$$

The battery selected is 45 Ah at 12 volts. Expected discharge time:

$$\text{Battery runtime} = \frac{45 \text{ Ah}}{2.20 \text{ A}} = 20.23 \text{ hours}$$

Average sunshine for the month of November in Ogbomoso, Nigeria is average of 10.63 hours (while for the whole year is average of 10.8 hour) (weather and climate.com. 2025).

The solar panel selected was rated at 60 W with 3.11 A output.

Daily battery charge = 3.11 A × 10.63 hours = 33.059 Ah

Time required to fully charge battery:

$$\text{Charging time} = \frac{45\text{Ah}}{33.059\text{A}} = 1.36 \text{ hours}$$

These calculations confirmed the mower's viability under expected load and operational conditions.

Battery sizing and solar input calculations were based on estimated power draw and average sunlight availability in Ogbomoso. With a design power of 33W and average daily solar irradiance of 10.63 hours, the system ensures the mower operates for over 20 hours without requiring an external power source. The solar panel charges at a rate of 33.059 Ah/day, allowing full recharge in approximately 1.4 hours of optimal sunlight.

Blade Configurations

Four distinct blade configurations were fabricated for comparative testing (Figure 2-4).

— Straight Blade (Standard Design)
— 2-Sided Blade (Symmetrical Cutters)
— 3-Sided Blade (Triangular Configuration)
— 4-Sided Blade (Cross Design)

All blades were made from mild steel and matched to a standard length of 190-250 mm. These blades were mounted interchangeably and subjected to cutting trials on grass samples.

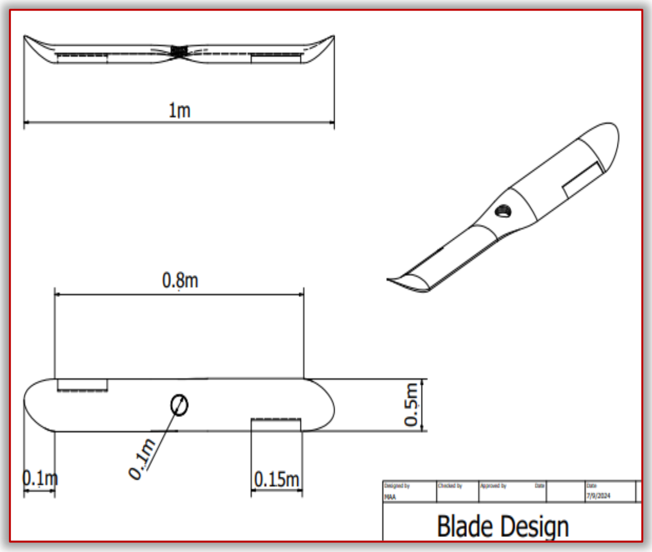

Figure 2: 2–sided Blade design

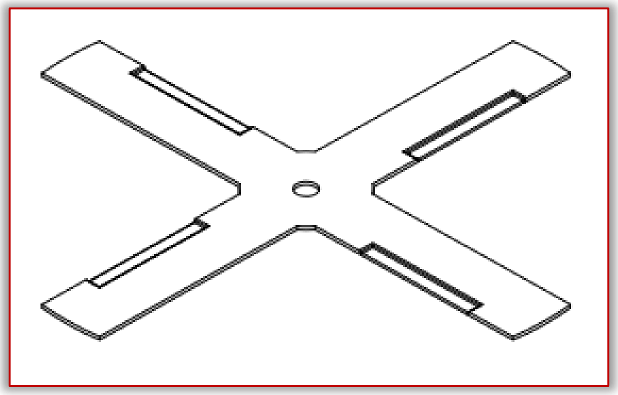

Figure .3: 4–sided Blade design

Figure 4: Fabricated Blades

Grass Type Selection and Field Testing

To simulate real-world variability, tests were conducted on three common grass types in Nigerian terrain:

- Milk Weed: Fine, soft-leaf species, typical of residential lawns
- Kentucky Bluegrass: Denser, more fibrous and moisture-rich
- SidaAcuta: Coarse, woody species typical of less maintained landscapes

Each grass type was trimmed in a defined 0.835 m^2 area under controlled conditions. The three common grass types are shown in Figure 5-7.

Figure 5: Operational Testing on SidaAcuta

Figure 6: SidaAcuta lawn area

Figure 7: Kentucky lawn area

Experimental Setup and Data Collection

Cutting time, efficiency, and cutting speed were recorded. Cutting efficiency was calculated using the formula:

$$\text{Efficiency (\%)} = \frac{\text{Area cut}}{\text{Total test area}} \times 100$$

Cutting speed was determined as:

$$\text{Speed (m/min)} = \frac{\text{Distance}}{\text{Time}}$$

Repeatability was ensured by performing each test three times and averaging the results. Observational data were also recorded on mower handling, resistance, and clogging issues.

RESULTS AND DISCUSSION

Performance Summary

The Fabricated Lawn Mower and results of the blade performance on across grass types were shown in Figure 8 and Table 1.

Table 1. Blade performance across grass types

Grass Type	Blade Type	Time (min)	Speed (m/min)	Efficiency (%)
Milk Weed	Straight	1.83	0.456	82.0
	2–sided	1.50	0.558	87.9
	3–sided	2.08	0.401	77.4
	4–sided	2.42	0.346	66.5
Kentucky Bluegrass	Straight	2.75	0.304	50.8
	2–sided	2.50	0.334	58.5
	3–sided	3.17	0.264	49.2
	4–sided	4.25	0.221	37.9
SidaAcuta	Straight	3.83	0.218	37.9
	2–sided	3.55	0.236	42.0
	3–sided	4.25	0.197	34.6
	4–sided	4.75	0.176	33.9

The straight blade ranked second, followed by 3-sided and 4-sided blades. The 4-sided blade experienced noticeable drop in efficiency, especially in fibrous and woody grass. Clogging was a major issue, impacting motor speed and drawing excess current, which could reduce battery life.

Figure 8: Fabricated Lawn Mower

Performance in Varied Terrains

In Milk Weed, which is fine and loosely packed, all blades performed relatively well, but the 2-sided blade recorded the highest speed. Kentucky Bluegrass presented more resistance; while the 2-sided blade still led in performance, the margin narrowed. SidaAcuta posed the most significant challenge due to its woody stem structure, with cutting efficiency dropping below 50% for all blades except the 2-sided.

Comparative Insights

Findings align with Soyoye (2021), who reported maximum cutting efficiency of 84.1% with rotary blades in a solar-powered setup. However, our 2-sided blade outperforms that under specific grass conditions, reaching 87.9% efficiency in Milk Weed. Igbokwe *et al.* (2019) highlighted similar mechanical designs but did not test varying blade geometries.

Satwik *et al.* (2015) emphasized mechanical adjustment systems to vary blade height via gear integration. While this work design did not include height adjustment, its comparative success reinforces the impact of blade geometry on cutting dynamics.

Studies like Tony (2006) demonstrate how slicing angles, blade tension, and geometry influence energy consumption in soft material cutting. This work results suggest that fewer blade edges (e.g., 2-sided) reduce energy dissipation and clogging — both vital factors for battery-powered systems.

DESIGN IMPROVEMENTS AND FUTURE WORK

While the prototype successfully demonstrated efficient lawn maintenance, potential improvements include:

- Integrating a dynamic blade height mechanism for adjustable cutting depth.
- Employing brushless motors for increased torque and lower maintenance.
- Using lighter composite materials for the frame to reduce total weight.
- Expanding the solar array to improve recharge time and duration.
- Adding sensors to monitor grass density and adapt blade speed dynamically.

Future research could also explore autonomous or semi-autonomous operation by integrating microcontroller systems (e.g., Arduino or Raspberry Pi), GPS modules, or obstacle-avoidance sensors for smart navigation.

CONCLUSION

The developed solar-powered lawn mower demonstrates high efficiency and adaptability across grass types, particularly when using a 2-sided blade. It operates quietly, reduces emissions, and eliminates fuel dependency. With enhanced mobility and tested performance under varied conditions, the mower presents a sustainable alternative for residential and institutional applications. The integration of low-cost, locally sourced materials further enhances its scalability and relevance in developing regions.

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