American Journal of Smart Technology and Solutions (AJSTS)

ISSN: 2837-0295 (ONLINE)

VOLUME 4 ISSUE 1 (2025)

PUBLISHED BY
E-PALLI PUBLISHERS, DELAWARE, USA

American Journal of Smart Technology and Solutions (AJSTS)

Volume 4 Issue 1, Year 2025
ISSN: 2837-0295 (Online)
DOI: https://doi.org/10.54536/ajsts.v4i1.4948
https://journals.e-palli.com/home/index.php/ajsts

Alpas: A Solar-Powered Weed Cutter with Obstacle Detection and Bluetooth-Based Smartphone Control for Sustainable Ground Maintenance

Marloun K. Gasoc[1*], Ronel G. Patunongon[1], Helton M. Gultiano[1], Jhul Jhe Necole A. Davines[1], Cristyl Dia B. Bondad[1]

Article Information

Received: April 05, 2025

Accepted: May 08, 2025

Published: June 24, 2025

Keywords

Bluetooth Control, Obstacle Detection, Renewable Energy, Solar-Powered Weed Cutter, Sustainable Ground Care

ABSTRACT

Maintaining large spaces, such as school grounds, is expensive, time-consuming, and labor-intensive. Gas-powered weed cutters are pollution-causing and expensive to run. ALPAS is a new, solar-powered, Bluetooth smartphone-controllable weed cutter with an obstacle detection system that provides a simple, cost-effective, and environmentally friendly weed control system. The system reduces its effect on the environment and its fossil fuel dependence by harnessing the power of solar energy to run its motors. An obstacle detection system is used to prevent malfunctions and ensure safe operation, while the Bluetooth smartphone control provides remote operation and enhances user convenience and efficiency. Performance testing compared ALPAS with conventional weed cutters in terms of power consumption, noise level, environment-friendliness, and cutting efficiency. The results established that ALPAS reduced fuel dependency, significantly reduced running costs, and provided reliable efficiency under different conditions. In addition, the performance of the system for green ground care was attested by the respondents' responses, which indicated acceptable responsiveness (4.74), ease of use (4.59), and reliability (4.97). ALPAS offers technological innovation in ground care providing a green and sustainable option that aligns with current sustainability agendas. Future development can focus on raising battery capacity and optimizing automated functions to further optimize its performance.

INTRODUCTION

Weed refers to any plant that proliferates in an unsuitable location at an inappropriate period, inflicting more harm than benefit. It is a plant that fights with crops for sunlight, nutrients, and water. This may lower land value and agricultural productivity while increasing maintenance costs. The degree of weed infestation in agricultural fields is greatly influenced by agronomic practices, such as crop rotation, tillage techniques, fertilization methods and timing, row spacing, seeding densities, herbicide application, crop selection, cultivar competitiveness, soil type, fertility status, and environmental conditions (Chauhan *et al.,* 2012; Swanton *et al.,* 2015). Because they compete with crop plants for nutrients, light, and water, weeds, as botanical pests, significantly lower agricultural productivity (Swanton *et al.,* 2015; Ramesh *et al.,* 2017). Conventional weeding methods rely on engine-based equipment or hand-operated scissors, which require significant man-hours and fuel, thus extending the period of operation. Hinatuan National Comprehensive High School possesses an extensive campus comprising a regular athletic oval with other green spaces. Significant resources are needed to maintain these grounds, both in terms of personnel and financial support, to keep it clean and attractive. This already calls for considerable commitment from our staff, as well as a significant percentage of the school's funds that could be otherwise used for other critical needs. Various studies have proven the efficiency of solar cutters, highlighting the advantage of the environment with a very practical means of lowering air and noise pollution, thus enabling users to beautify their grass and conserve their health. There exists a significant gap in the literature on an automatic solar weed cutter integrated with an obstacle detection system and with Bluetooth smartphone control that allows for operation without human intervention. This project, ALPAS: A Solar-Powered Weed Cutter with Obstacle Detection and Bluetooth-Based Smartphone Control for Sustainable Ground Maintenance, seeks to address one very important felt need in Hinatuan National Comprehensive High School. The innovative technology, which functions with solar energy and intends to minimize dependency on fossil fuels, offers sustainability and hence minimizes the carbon footprint of conventional weed cutters. It is fitted with an obstacle detection system to guarantee that it operates safely thereby avoiding potential accidents and protecting adjoining objects. Besides that, the Bluetooth-enabled smartphone control means that this equipment can be controlled from a smartphone, offering an easy interfacing method for remote operation that is simple yet highly accurate. ALPAS can assist the school by maximizing the value of resources, minimizing manual work, and improving overall effectiveness. Apart from the evident practicality of these benefits, the project also proves the institution's commitment to sustainable practices, safety, and innovation. This weed cutter provides a contemporary weave into landscape maintenance, marrying renewable energy systems, leading-edge technology, and cost-effectiveness. In other words, the project responds to immediate requirements of

[1] Department of Education, Caraga Region, Surigao del Sur Division, Hinatuan National Comprehensive High School, Philippines
[*] Corresponding author's e-mail: marloun.gasoc@deped.gov.ph

the school and, at the same time, becomes a benchmark for sustainable solutions in schools and public places on a larger scale.

LITERATURE REVIEW

In the past, grass cutters were portable, manually operated machines. They lost energy and caused pollution by using gas and petrol engines. Because of this, automatic grass cutters that rely on a battery for steering and obstacle detection must take the place of manual lawn cutters. A linear blade for cutting grass, an ultrasonic sensor for object identification, a motor drive for the robot's wheels, and an Arduino UNO microcontroller board served as additional components. In 2017, Another automated solar grass cutter that runs on solar power was introduced by Yadav *et al.* (2017) the paper describes the development of a mobile, solar-powered grass-cutting tool that may be used as a backup in the event of an electrical outage. The robot has a solar panel attached to it that is connected to a battery. An inverter that is attached to the battery transforms DC current from the solar panel into AC current, which turns on the AC motor. The motor spins the blade quickly, cutting the grass efficiently. It is attached to the blade shaft by a belt drive. This invention advances the development of an environmentally friendly system. In terms of technology, manual lawn cutting equipment is still the most widely used. In the study conducted by N, M. S. B. (2017), researchers explored the development of a hybrid solar-powered lawn mower designed to overcome the limitations associated with traditional grass-cutting machines. The primary objective was to reduce human effort, lower operational costs, and minimize maintenance expenses, all while eliminating the dependence on fuel.

The amount of effort required for weeding depends on the type of weed, its intensity, the time needed, and the worker's productivity. Farmers now view the weed cutter as a multifunctional piece of agricultural machinery. It is sold by several businesses in the market and comes in 2-stroke and 4-stroke types with different capacities. Well-known 2-stroke variants include lightweight aluminum bodies and gasoline engines that produce between 1.8 and 2.1 horsepower. Depending on usage, these models can use 600 to 900 milliliters of oil-mixed gasoline per hour (Mohite *et al.*, 2021). Amrutesh *et al.* (2014) introduced their research on a yoke mechanism for agriculture, aiming to reduce weed through enhanced cutting efficiency while ensuring operator comfort. They used the crank slider to apply power and found it significantly better than mechanically powered vehicles. Pramod *et al.* (2014) designed and fabricated weed cutting systems to solve these problems sustainably. They developed a platform made of recyclable materials including PVC pipes, and buoyancy tanks made from paint cans, as well as new designs for the cutter head. Designed to be an economic solution for aquatic weed management, this machine does the job of removing floating, submerged, or partially submerged vegetation. P.V.V.S. Maneendra *et al.* (2020) designed a motorized farm weeder with a grass collector to effectively remove and collect weeds and debris present between crops. The primary aim of their work was to minimize the time required to remove weeds between plants, thus improving agricultural productivity. According to Mandloi *et al.* (2010), the cost-efficient shrub-cutting machine was developed through field testing involving measurements of torque and force as well as assessments of load and speed based on the specified design criteria.

This research highlights the potential of renewable energy technologies in enhancing the efficiency and sustainability of landscaping practices, as solar-powered mowers can significantly reduce carbon footprints compared to their traditional counterparts. For more detailed insights, you can refer to the original study by N, M. S. B. (2017). A robot that avoids obstacles by using two gear motors to generate simple walking motions. They developed a highly intelligent robot that can quickly identify impediments and, by analyzing the sensor's data, perfectly avoid them on its path. The robot's smooth movement is achieved by utilizing two gear motors to enable left, right, or forward movement in response to detected input. Infrared sensors were used to identify and avoid obstacles on the way. Infrared transmitters are used to continually emit a 38 KHz signal.

MATERIALS AND METHODS

Research Design

This study takes a developmental design method to create and evaluate a solar-powered weed cutter that can be controlled by a Bluetooth-enabled smartphone and includes obstacle identification. The design combines technical concepts with sustainability and usability considerations to effectively address the challenge of efficient ground maintenance.

Development Procedures

The development procedure concerning a weed cutter prototype initiated by methodical assembly of the prototype actors. All components are assembled according to their design specifications, followed by electrical wiring and connection of the equipment and safe operational test and functional performance. Subsequently, there is programming and calibration to develop and fine-tune the code for precise motor control and accurate obstacle detection. Once assembled and programmed, the prototype was put through thorough testing to ascertain its overall performance, functionality, and reliability, including the responsiveness and ease of use of the Bluetooth-based smartphone control system for remote operation. The weed cutter was then tested in the field on the school grounds, where its effectiveness and usability could be determined under real conditions. In this phase, data is collected and analyzed for potential improvements to be introduced in the design of the prototype. Finally, the whole process was documented well, and monitoring was done regarding findings that would bring useful insights and recommendations for further development and practical implementation of the grass cutter.

Data Analysis

For the testing and validation process, the procedure follows the methodology presented by Kumbar *et al.* (2024).

1. Prototype analysis involved taking readings at designated time intervals with a Temperature Gun, Solar Power Meter, and Multimeter to evaluate the solar panel system's performance.
2. The Temperature Gun measured the solar panel's temperature by directing the device at the panel, yielding Celsius readings that offered insights into the thermal conditions impacting the panel's efficiency.
3. A Solar Power Meter was utilized for the observation of sunshine intensity. The apparatus was faced towards both the sun and the solar panel, registering watts per square meter (W/m^2). This parameter is essential for determining how much solar energy is available for conversion.
4. A multimeter was used to take measurements of voltage outputs at equidistant time intervals coming from the solar panel. Voltage readings provide ample data concerning the electrical output of the panel.

System Performance Analysis

The system performance evaluation was done by considering the methods suggested by Kalpana *et al.* (2024), followed by the power consumed, battery availability, run time, and cutting efficiency. Calculations give insight into the general optimization of system performance to ensure a better operating economy and battery management. To evaluate Bluetooth-based smartphone control system responsiveness, usability, and reliability in the operation and management of grass cutters from a distance, a structured questionnaire was created by researchers. The questionnaire was thoroughly validated by research experts to make sure it was relevant, accurate, and reliable as a data-gathering tool. A total of 40 respondents were selected through purposive sampling, including parents, school administrators, faculty members, and personnel. Each group consisted of 10 participants.

RESULTS AND DISCUSSION

Table 1: Comparison of Conventional and Solar-Powered Weed Cutters

Parameter	Conventional Weed Cutter	Solar-Powered Weed Cutter
Power Source	Gasoline/Electric	Solar Panel (Renewable)
Fuel/Energy Cost	Required	Not required
Environmental Risk	High (gasoline)/Moderate (Electricity)	Low (Eco-Friendly)
Noise Level	High	Potentially Lower (Electric Motor
Operation	Manual control	Bluetooth-Controlled (Smartphone Interface)
Automation	Unavailable	Fully automated via smartphone
Cost-effectiveness	Expensive	Cost-effective (Low maintenance)

Table 1 highlights the key differences between conventional and solar-powered weed cutters. Conventional weed cutters, powered by gasoline or electricity, have ongoing fuel costs and pose higher environmental risks, especially from gasoline emissions. In contrast, solar-powered weed cutters utilize renewable solar energy, eliminating fuel costs and reducing environmental impact. Conventional models tend to be noisy, while solar-powered versions, with electric motors, are quieter. Additionally, solar-powered weed cutters often provide non-manual which is Bluetooth-controlled (smartphone), fully automated controlled via smartphone, enhancing user convenience, while conventional models require manual operation and not automated. Overall, solar-powered cutters are more cost-effective and environmentally friendly. According to Kashyap *et al.* (2020), mowing grass takes a lot of time and effort. These days, most of the technology available for cutting grass is a manually operated diesel cutter. These kinds of devices that run on unconventional energy sources harm the environment, release greenhouse gases, and contribute to climate change. Additionally, these weed eaters contribute to noise pollution, which hurts both the cutter's and the nearby population's health. Another factor is that diesel fuel is expensive. A solar-powered autonomous grass cutter is being developed to combat the problems of the conventional cutter.

The search for alternative energy sources has accelerated due to the dwindling fossil resources. Researchers are exploring several alternatives, particularly solar energy, which has become an important aspect of various projects (Lingappa *et al.,* 2024). Solar technology is new in the solar weed cutter, a simple yet effective machine used to manage lawns locally, in gardens, and in schools (Amrutesh *et al.,* 2014). In view of its solar energy operation and high RPM for effective grass cutting, this autonomous weed-cutting vehicle is very new (Athina *et al.,* 2021). Such eco-friendly devices are cost-efficient, consume little power, and thus are suitable for sustainable landscaping (Mudda, 2018).

A gas-powered Kawasaki Grass Cutter, priced at ₱13,200, has become rather famous for possessing that high initial cost typical of fossil fuel driven machines. The ALPAS Solar-powered Weed Cutter, in contrast, has a price of just ₱4,500; this is cheaper mainly because of the low

Table 2: Cost-Analysis of Traditional Grass Cutter and Solar-powered Weed Cutter

TYPE	COST
Vic Kawasaki K TD-40 2 Stroke Grass Cutter (Source: KHM Mega Tools Corp.)	₱ 13,200
ALPAS: Solar-powered Weed Cutter	₱ 4,500

production costs associated with solar technology and the lack of complicated engine parts. Though the solar cutter is cheaper at the front, it has a much lower cost on operation in the far future. Traditional lawn cutters have persistent costs of fuel and maintenance; these costs can increase with time depending on fluctuating fuel prices and the need for frequent servicing. The solar models conserve renewable energy, so their operation after the initial purchase is almost free. Research shows these projects can be singled out because they do not have an operational cost, which is due to having no fuel charges and much less maintenance compared to gas (Kirtiwar *et al.,* 2023). Also, via reducing environmental impacts from the use of tools run by the sun (Babu *et al.,* 2023). While conventional grass cutters make huge noise and, through combustion of fuel, contribute to greenhouse gas emissions, solar-powered cutters are markedly silent and do not emit any such pollutants, hence providing a sustainable option for lawn maintenance (Kalpana *et al.* 2024).

Table 3: Testing and Evaluation

Time (min.)	Temperature (°C)	Voltage (V)	Intensity of Sunlight (W/m²)	Intensity of Solar Panel (W/m²)
9:30 A.M.	45	18.4	878	169
10:00 A.M.	43	19.28	945	156
10:30 A.M.	46	19.18	981	187
11:00 A.M.	49	19.16	991	189
11:30 A.M.	52	18.78	1046	195
12:00 P.M.	55	18.74	1058	235
12:30 P.M.	54	19.03	1054	243
1:00 P.M.	56	18.75	1020	224
1:30 P.M.	52	19.17	1016	221
2:00 P.M.	55	19.14	1010	220
2:30 P.M.	53	19.10	994	205
3:00 P.M.	50	19.80	989	202

The solar panel system testing and assessment were executed in Table 3, with temperature, voltage, sunshine intensity, and output from solar panels being measured from around 9:30 A.M. to about 3:00 P.M. The voltage generated in this solar panel system remained constant, going as low as 18.4 V at 9:30 A.M. to as high as 19.8 V at 3:00 P.M. This value, however, indicates that the power output is thereafter stabilized and protected from variations in the environment. At 12:00 noon, solar intensity reached its highest value of 1058 W/m², followed at 12:30 P.M. with the solar panel output of 243 W/m². Beyond this value, the intensity of sunlight and solar panel output began to fall, especially around 1:30 P.M. However, output voltage hardly showed any deviation, suggesting that the panel worked well despite being in adverse conditions of declining solar intensity. The temperature readings kept rising constantly throughout the day, starting from 45°C at 9:30 A.M. up to 56°C by 1:00 P.M. Nevertheless, high temperatures were not markedly detrimental to the operation of the system, thus proving the endurance as well as utility of the panel in extreme heat. The data show that the equipment runs well and absorbs solar energy during the day, irrespective of the weather conditions. This substantiates the reliability and practicality of solar panels as sources of energy for various applications.

Table 4 depicts the performance of the solar-powered weed cutter on different grass species. The average height for crabgrass was cut from 224 mm to 85 mm, a significant height reduction. Goosegrass went similarly

Table 4: Average Weed Height Before and After Cutting Using the Solar-Powered Weed Cutter

Weeds Type	Average Height Before Moving (mm)	Average Height After Moving (mm)
Crabgrass (Digitaria ischaemum)	224	85
Goosegrass (Eleusine indica)	234	90
Quackgrass (Elytrigia repens)	70.5	50.5

from 234 mm to 90 mm. Quack grass was reduced from an earlier height of 70.5 mm down to 50.5 mm. These results indicate that the solar cutter performs well on different grass species and effects a reasonable reduction in height. The slight deviation in heights for crabgrass can be attributed to the fact that the species has a naturally lower growth height, indicating that the cutter is efficient for taller as well as shorter grass species. Such variability further establishes the cutter's versatility and efficacy in treating different grass species, indicating its viability for several landscaping applications.

Table 5: System performance analysis

Aspect	Formula	Results
Power Consumption per Motor (P_m)	$P_m=V_m \times I_m$	58.9W
Total Power Consumption (T_{pc})	$T_{pc}=P_m \times 4$ motors	235.6W
Usable Battery Capacity (C_{usable})	$C_{usable}=C_{battery} \times 0.85$	68Ah
Estimated Runtime	$R=(C_{usable}/I_{total})$	415.2 min
Effective Cutting Width ($Effective_{cw}$)	$Effective_{cw}$=(1000mm/(Cutting Width×Cutting Ratio))	0.1736 meters
Distance Cut per Rotation (D_r)	D_r=Effective Cutting Width	0.19 meters
Distance Cut per Minute (D_r)	$D_{cpm} = D_r \times RPM$	11.4 meters per min

Multiple critical performance parameters show how successful the solar-powered grass cutter is. Each motor consumes 58.9 W of power, totalling 235.6 W for the complete system. This clever use of energy is critical for optimizing battery performance. The lawn mower's battery capacity of 68 Ah allows it to run for approximately 415.2 minutes. This longer runtime means that the lawn cutter can function for a long period before needing to be recharged, making it ideal for cutting grass in large areas. The machine has an effective cutting width of 0.1736 meters, making grass maintenance simple. It cuts 0.19 meters of space each time it turns, resulting in a rate of 11.4 meters per minute. This cutting speed allows users to complete more tasks in less time, increasing productivity.

Table 6 : Overall Evaluation of Bluetooth-Based Control System

Criterion	Weighted Mean	Descriptive Equivalent	Interpretation
Responsiveness	4.74	Strongly Agree	The system performs exceptionally well in meeting the stated expectations and functionalities.
Ease of use	4.59	Strongly Agree	The system performs exceptionally well in meeting the stated expectations and functionalities.
Reliability	4.97	Strongly Agree	The system performs exceptionally well in meeting the stated expectations and functionalities.
Average	4.76	Strongly Agree	The system performs exceptionally well in meeting the stated expectations and functionalities.

The responsiveness, with a weighted mean score of 4.74, is commendable. Research corroborates this, demonstrating that Bluetooth technology enables real-time communication and control, essential for responsive systems. Juned and Unnikrishnan (2014) illustrate that a Bluetooth-based remote monitoring and control system achieved rapid data transmission within 10 seconds, allowing swift operator responses to fluctuations in monitored parameters such as temperature and humidity. This aligns with user feedback emphasizing the system's ability to meet operational demands promptly. The 4.59 ease of use score indicates that consumers find the system straightforward and easy to navigate. Kulkarni *et al.* (2019) show that merging Bluetooth with mobile applications improves user interaction with home automation systems, making them more accessible to persons with minimal technical abilities. Creating user-friendly interfaces is critical for improving user experience, as evidenced by numerous research on smart home technology. The ease of use improves user happiness and overall system acceptance. A reliability score of 4.97 implies extremely consistent performance. Users rely on control systems to provide precise oversight and management; therefore, reliability is critical.

Liu and Uthra (2020) corroborate this assertion by demonstrating that Bluetooth-enabled systems may sustain robust connections across long distances (up to 60 meters), ensuring continued functionality. This dependability builds trust among users, improving their overall impression of the system. The mean score of 4.76 validates the positive assessment of the Bluetooth-controlled system. This total satisfaction can be due to the combined impacts of high responsiveness, ease of use, and dependability. Several studies imply that these factors are inextricably related; a dependable and attentive system improves the user experience.

CONCLUSIONS

ALPAS is a breakthrough model for weed management that is both sustainable and environmentally responsible. It is ideal for huge spaces like schools, parks, and large offices. This environmentally friendly weeding device is solar powered, which reduces running expenses and eliminates the need for gasoline. Thus, it generates significant savings while also helping environmental sustainability. ALPAS is fueled by solar energy on a continual basis under varying light conditions. A specially built panel guarantees that the machine receives the constant power it requires to work in low-light circumstances. This characteristic ensures stability and consistent performance, which is especially useful for outdoor maintenance. The obstacle-detection feature is a standout among remarkable safety improvements. With this function, ALPAS may detect impediments and navigate them without assistance, boosting operational safety. This is especially critical when the user's safety and comfort are at risk. To enhance the user experience, smartphone control via Bluetooth enables remote operation and real-time monitoring. This smart functionality improves simplicity of use by allowing users to control the machine remotely and alter settings for specific jobs. ALPAS is a significant step forward for green landscaping alternatives due to its solar-power efficiency, safety-focused obstacle identification, and digital connectivity.

REFERENCES

Alagarsamy, S., Subramanian, R. R., Bobba, P. K., Jonnadula, P., & Devarapalli, S. R. (2021). Designing a smart speaking system for voiceless community. In *Lecture notes in networks and systems* (pp. 21–34). https://doi.org/10.1007/978-981-16-2126-0_3

Amrutesh, P., Sagar, B., & Venu, B. (2014). Solar grass cutter with linear blades by using Scotch yoke mechanism. *International Journal of Engineering Research and Applications, 4*(9), 10–21. https://www.researchgate.net/publication/33695249_Solar_Grass_Cutter_with_Linear_Blades_By_Using_Scotch_Yoke_Mechanism

Athina, D., Kumar, D. K., Kalyani, R., & Vittal, K. (2021). Solar grass cutter using embedded platform experimental validation. *IOP Conference Series Materials Science and Engineering, 1057*(1), 012086. https://doi.org/10.1088/1757-899x/1057/1/012086

Babu, V. R., Elumalai, S., Sharon, V. M., Yogesh, S., & Raj, J. I. L. (2023). Smart grass cutter using solar power system. *Tuijin Jishu/Journal of Propulsion Technology, 44*(6), 5285.

Chauhan, B. S., Singh, R. G., & Mahajan, G. (2012). Ecology and management of weeds under conservation agriculture: A review. *Crop Protection, 38*, 57–65. https://doi.org/10.1016/j.cropro.2012.03.010

Deriquito, J. (2021). *When should a timing chain be replaced?* AutoDeal. Retrieved May 9, 2025, from https://www.autodeal.com.ph/articles/car-features/when-should-timing-chain-be-replaced

Juned, M., & Unnikrishnan, S. (2014). Bluetooth-based remote monitoring & control system. *Journal of Basic and Applied Engineering Research, 1*, 108–111. © Krishi Sanskriti Publications. http://www.krishisanskriti.org/jbaer.html

Kalpana, M., Sravani, P., Sravya, J., Varma, M. A. K., Lokesh, P., Sivani, B. L., & Hemanth, P. S. (2024). Development and Analysis of a Solar-Powered Grass Cutter with Integrated Collector Using IoT. *Engineering Proceedings, 66*(1), 43. https://doi.org/10.3390/engproc2024066043

Kashyap, D., Bordoloi, U., & Buragohain, A. A. (2020). Design of a fully automated solar grass cutter for campus cleaning. *International Journal of Creative Research Thoughts (IJCRT), 8*(5). https://ijcrt.org/papers/IJCRT2005330.pdf

Kirtiwar, V., Mahale, J., Chaure, M., Khode, P., & Ahire, V. (2023). Design and fabrication of solar powered grass cutter. *International Journal of Progressive Research in Engineering Management and Science, 3*(5), 1111–1116. https://www.ijprems.com

Kulkarni, B. P. (2019). Home Automation using Bluetooth Control Technology. *International Journal for Research in Applied Science and Engineering Technology, 7*(4), 2136–2140. https://doi.org/10.22214/ijraset.2019.4386

Kumbar, G. M., Konduskar, S., Patil, Y., Konduskar, P., Milake, R., & Patil, S. (2024). Automatic solar grass cutter. *International Journal of Research Publication and Reviews, 5*(4), 8408–8412. https://www.ijrpr.com

Lingappa, J., Raghavender, V., Aparna, G., & Manideep, Ch. (2024). *Automated grass cutter using renewable energy.* EDP Sciences. https://creativecommons.org/licenses/by/4.0/

Liu, Y., & Uthra, R. A. (2020). Bluetooth based smart home control and air monitoring system. *International Journal of Advanced Research in Engineering and Technology, 11*(5), 264-274. http://iaeme.com/Home/issue/IJARET?Volume=11&Issue=5

Mandloi, R. K., Gupta, R. K., & Rehman, A. (2010). Design, development and testing of low capital and operational cost shrub cutting machine. *Journal of Rangeland Science, 1*, 121–124.

Maneendra, P. V. V. S., Rajesh, S., Kumar, V. S., Raju, M. B., & Kumar, K. S. (2020). Fabrication of motorized agriculture weeder with grass collector. *Journal of Emerging Technologies and Innovative Research (JETIR), 7*(3). https://www.jetir.org

Mohite, D. D., Agrawal, K., Kumar, K., & Deb, A. (2021). Technical aspects of multipurpose weed cutter or power weeder. *International Journal of Enhanced Research in Science, Technology & Engineering (IJERSTE), 10*(7), 35. https://doi.org/10.13140/RG.2.2.11613.33765

Mudda, M., Teja, V., Mudd, S., & Kumar, P. (2018). Automatic solar grass cutter. *International Journal for Research in Applied Science & Engineering Technology, 6*(4), 1148–1151. https://www.researchgate.net/publication/325221845_Automatic_Solar_Grass_Cutter

N, M. S. B. (2017). Design and development of hybrid powered grass cutter. *International Journal for Research in Applied Science and Engineering Technology, V*(III), 657–662. https://doi.org/10.22214/ijraset.2017.3123

N, M. S. B. (2017b). Design and development of hybrid powered grass cutter. *International Journal for Research in Applied Science and Engineering Technology, V*(III), 657–662. https://doi.org/10.22214/ijraset.2017.3123

Neha, N., & Asra, S. (2018). Automated grass cutter robot based on IoT. *International Journal of Trend in Scientific Research and Development, 2*(5), 334–337. https://doi.org/10.31142/ijtsrd15824

Pandit, A. (2019, March 12). *Obstacle avoiding robot using Arduino and ultrasonic sensor*. CircuitDigest. https://circuitdigest.com/microcontroller-projects/arduino-obstacle-avoding-robot

Pramod, R., Sandesh, M. D., Jayaram, M. S., & Kalasagarreddi, K. (2014). Design and development of sustainable weed cutter. *International Conference on Engineering of Complex Computer Systems,* 287–292. https://doi.org/10.1109/iceccs.2014.65

Ramesh, K., Matloob, A., Aslam, F., Florentine, S. K., & Chauhan, B. S. (2017). Weeds in a changing climate: Vulnerabilities, consequences, and implications for future weed management. *Frontiers in Plant Science, 8*. https://doi.org/10.3389/fpls.2017.00095

Yadav, R. A., Chavan, N. V., Patil, M. B., & Mane, V. A. (2017, February). Automated solar grass cutter. *International Journal of Scientific Development and Research (IJSDR), 2*(2), 65–69. https://ijsdr.org/papers/IJSDR1702016.pdf

Yadav, R. A., Chavan, N. V., Patil, M. B., & V. A. Mane. (2017). AUTOMATED SOLAR GRASS CUTTER. In *International Journal of Scientific Development and Research (IJSDR), 2*(2), pp. 65–66). https://ijsdr.org/papers/IJSDR1702016.pdf