iJRASET
International Journal For Research in Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 14 **Issue:** IV **Month of publication:** April 2026

DOI: https://doi.org/10.22214/ijraset.2026.76414

www.ijraset.com

Call: 08813907089 | E-mail ID: ijraset@gmail.com

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 14 Issue IV Apr 2026- Available at www.ijraset.com

Sustainable Solar-Powered Seed Sower for Smart Agriculture

Akshatha J[1], Manasa J P[2], C Y Jeevitha[3]
Assistant Professor, Department of Electronics & Communication Engineering, GSSSIETW, Mysuru

Abstract: ***This paper presents the design and implementation of a solar-powered, Bluetooth-controlled agricultural seeding robot intended to automate seed sowing with improved precision and reduced manual effort. The system employs an ESP32-WROOM microcontroller as the central control unit, enabling wireless operation through a mobile-based Bluetooth interface. Robot mobility is achieved using four 100 RPM DC BO motors driven by L298N motor drivers, ensuring stable navigation across agricultural terrain. A servo-operated seed dispensing mechanism releases seeds at fixed intervals, providing uniform spacing and minimizing seed wastage. Power is supplied by a 2-cell Li-ion battery, which is continuously charged using a 12 V solar panel and buck converter, allowing extended operation in off-grid environments. The proposed system demonstrates a cost-effective, energy-efficient, and sustainable solution suitable for small and medium-scale farming applications.***
Keywords: Solar-powered agriculture, Seed sowing robot, ESP32, Bluetooth control, Precision farming, Renewable energy.

I. INTRODUCTION

Agriculture remains a vital sector for economic growth and food security, especially in developing countries where a significant portion of the population depends on farming for livelihood. However, traditional agricultural practices such as manual seed sowing are labor-intensive, time-consuming, and often result in uneven seed distribution. These limitations directly affect crop uniformity, productivity, and overall yield [11], [12]. At the same time, conventional mechanized farming equipment is expensive, fuel-dependent, and often unsuitable for small and medium-scale farms due to high operational and maintenance costs [3], [8].

Recent advancements in embedded systems, robotics, and renewable energy have enabled the development of smart agricultural solutions aimed at improving efficiency and sustainability. Automated seeding and spraying systems powered by renewable energy sources have been shown to significantly reduce human effort while ensuring improved operational efficiency and precision [1], [2], [4]. Among these technologies, solar-powered robotic platforms offer a clean and cost-effective alternative by reducing dependency on fossil fuels and grid electricity while supporting precision farming practices [5], [8].

This paper presents a solar-powered, Bluetooth-controlled agricultural seeding robot designed to address the challenges of manual sowing and energy consumption. The proposed system integrates an ESP32-WROOM microcontroller for wireless control, DC motors for field mobility, and a servo-based mechanism for precise seed dispensing. A solar charging unit continuously replenishes the onboard battery, enabling extended operation in off-grid environments. Similar solar-powered seed sowing and agricultural robotic systems have demonstrated the feasibility of such approaches, motivating the proposed design [9], [10]. The system aims to support precision farming practices by improving seeding accuracy, reducing labor requirements, and promoting sustainable agricultural operations.

II. LITERATURE SURVEY

Recent research in agricultural automation indicates a growing emphasis on integrating renewable energy sources with smart farming equipment to enhance operational efficiency and environmental sustainability. Many studies have explored the replacement of conventional fuel-based agricultural tools with solar-powered alternatives to reduce operating costs, energy consumption, and environmental impact [1], [8].

Sinha et al. developed a solar-powered knapsack sprayer as an alternative to petrol-driven spraying equipment, demonstrating improved energy efficiency and elimination of fuel dependency [1]. The system primarily focused on spraying applications and emphasized ease of use and environmental benefits; however, it did not address automation or precision in seed placement. Similarly, Fuzafaraz et al. presented a solar-powered sprayer powered by rechargeable batteries, which showed reliable performance in off-grid agricultural regions but lacked mechanisms for controlled or automated seeding operations [2].

©IJRASET: All Rights are Reserved

Singh and Verma proposed a solar-powered multi-purpose sprayer aimed at improving portability and reducing manual labor [3]. Although the system was effective for spraying and irrigation-related tasks, it did not incorporate intelligent control features or robotic mobility. In another study, Ramesh et al. designed a solar-powered seed and fertilizer dispensing system using a microcontroller-based metering mechanism to enhance dispensing accuracy [4]. While this approach improved input control, the system lacked mobility and wireless user interaction, limiting its applicability for large field operations.

With advancements in embedded systems and wireless communication, Sharma and Pandey introduced an IoT-based solar agricultural robot that integrated sensors and communication modules for precision farming applications [5]. Although the system demonstrated the potential of smart technologies in agriculture, increased system complexity and cost posed challenges for small and medium-scale farmers. Sathapare et al. developed a solar-powered seed spraying machine capable of achieving relatively uniform seed distribution; however, manual operation and limited precision control reduced its effectiveness [6]. Other multifunctional solar-powered agricultural systems have also been reported, combining spraying and seed sowing operations, but often with limited automation and control flexibility [7].

From the reviewed literature, it is evident that solar-powered agricultural systems have shown promising outcomes in reducing fuel dependency and improving sustainability. However, many existing solutions lack key features such as precise seed spacing, robotic mobility, and simple wireless control interfaces [9], [10]. Manual and semi-automated seed sowing machines further highlight the need for improved precision and reduced labor dependence [11], [12]. The proposed system addresses these limitations by integrating Bluetooth-based wireless control, servo-driven precision seed dispensing, and solar-assisted power management into a compact and cost-effective robotic platform suitable for small and medium-scale farming applications.

III. SYSTEM ARCHITECTURE AND METHODOLOGY

The proposed solar-powered agricultural seeding robot is designed as a compact and efficient robotic platform that integrates mobility, wireless control, automated seed dispensing, and renewable energy harvesting. The overall system architecture is centred around an embedded controller that coordinates all hardware modules to achieve precise and reliable seeding operations.

A. System Architecture

The overall architecture of the proposed agricultural seeding robot is centered around the ESP32-WROOM microcontroller, which functions as the main control unit of the system. It receives user commands via Bluetooth communication and coordinates both the locomotion of the robot and the operation of the seed dispensing mechanism. The ESP32 is chosen due to its low power consumption, high processing capability, and integrated Bluetooth support, making it well suited for real-time control in smart agricultural applications [5], [10].

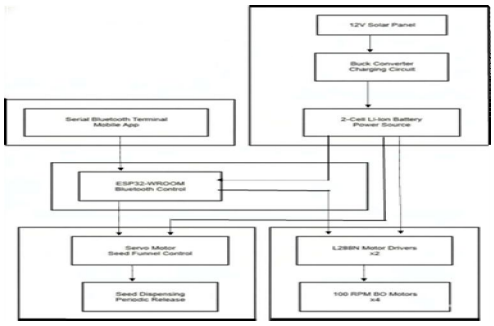


Fig. 1. Block diagram of the proposed solar-powered Bluetooth-controlled seed sowing robot.

Fig. 1 illustrates the block diagram of the proposed solar-powered seed sowing robot. The mobility subsystem comprises four 100 RPM DC BO motors, each driven by an L298N motor driver module. This motor driver configuration enables bidirectional motor control and smooth speed regulation, allowing the robot to perform forward, reverse, and turning manoeuvres with stability. The four-wheel-drive arrangement improves traction and manoeuvrability on uneven agricultural terrain, which is essential for field-level operations [9], [10]. For seed sowing operations, a servo motor–based dispensing mechanism is employed. The servo motor controls the opening and closing of a funnel outlet at predefined time intervals, ensuring uniform seed release and consistent spacing between seeds. This automated dispensing approach reduces seed wastage and overcomes irregularities commonly observed in manual sowing methods, thereby improving planting accuracy [4], [11].

©IJRASET: All Rights are Reserved | SJ Impact Factor 7.538 | ISRA Journal Impact Factor 7.894 |

The power subsystem consists of a 2-cell Li-ion battery pack that supplies energy to all electronic components. To enhance system autonomy and sustainability, a 12 V solar panel is integrated with a buck converter–based charging circuit, which regulates the charging voltage and safely replenishes the battery during daylight operation. This hybrid power arrangement enables prolonged usage in off-grid and rural farming environments while reducing reliance on external power sources [1], [8].

B. Methodology

The operational methodology of the proposed system begins with establishing Bluetooth communication between the ESP32-WROOM microcontroller and a smartphone-based Bluetooth serial terminal application. Through this mobile interface, the user transmits directional and operational commands, which are wirelessly received and interpreted by the microcontroller for further processing [5], [10].

The mobility performance of the robot was observed to be stable on soil and uneven surfaces. The four 100 RPM DC BO motors, controlled using L298N motor drivers, provided adequate torque and smooth motion for forward, reverse, and turning operations. The four-wheel-drive configuration enhanced traction and stability, enabling efficient coverage of the agricultural field area [9], [10].

The seed dispensing mechanism exhibited consistent and uniform seed placement during operation. The servo motor–controlled funnel released seeds at fixed time intervals, resulting in evenly spaced seed distribution along the robot's path. This automated dispensing approach minimized seed wastage and eliminated irregularities commonly associated with manual sowing techniques. The observed accuracy in seed placement confirms the suitability of servo-based mechanisms for precision farming applications [4], [11].

Wireless control using Bluetooth provided a simple and intuitive user interface for system operation. Commands transmitted through the smartphone-based Bluetooth terminal application were accurately received and executed by the ESP32 microcontroller with negligible latency. This enabled real-time control of both robot navigation and seed dispensing functions without the need for complex control hardware [5].

The power management subsystem performed efficiently throughout the testing phase. The Li-ion battery supplied stable power to all electronic components, while the integrated solar panel continuously recharged the battery via the buck converter during operation. This hybrid power configuration extended the operational time of the robot and reduced reliance on external charging sources, making the system well suited for rural and off-grid farming environments [1], [8].

Overall, the experimental results confirm that the proposed system effectively integrates automation, renewable energy, and wireless control. The robot demonstrated reliable navigation, precise seed placement, and sustainable operation, validating its applicability for small and medium-scale agricultural practices.

IV. RESULTS AND DISCUSSION

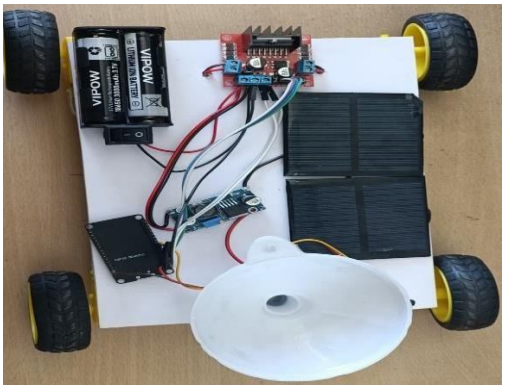


Fig. 2. Fabricated prototype of the solar-powered Bluetooth-controlled agricultural seed sowing robot.

The proposed solar-powered Bluetooth-controlled agricultural seed sowing robot was successfully fabricated, as shown in Fig. 2, and evaluated under controlled experimental conditions to analyze its performance in terms of mobility, seed dispensing accuracy, wireless control reliability, and power efficiency. The experimental observations confirmed effective coordination among the control unit, drive system, seed dispensing mechanism, and power subsystem.

The mobility performance of the robot was observed to be stable on soil and moderately uneven surfaces. The four 100 RPM DC BO motors, driven by L298N motor driver modules, provided sufficient torque and smooth motion for forward, reverse, and turning operations. The four-wheel-drive configuration enhanced traction and ensured balanced movement, enabling efficient coverage of the agricultural field area. Similar mobility behavior has been reported in earlier solar-powered agricultural robotic systems [9], [10].

The seed dispensing mechanism demonstrated consistent and uniform seed placement during operation. The servo motor–controlled funnel released seeds at fixed time intervals, resulting in evenly spaced seed distribution along the robot's traversal path. This automated dispensing approach significantly reduced seed wastage and eliminated irregular distribution commonly associated with manual seed sowing methods. The achieved precision confirms the effectiveness of servo-based metering mechanisms for precision farming applications [4], [11].

Wireless operation using Bluetooth provided a simple and user-friendly control interface. Commands transmitted through the smartphone-based Bluetooth serial terminal application were accurately received and executed by the ESP32-WROOM microcontroller with minimal latency.

This enabled real-time control of robot navigation and seeding functions without the need for complex control hardware, aligning with findings from earlier smart agricultural robotic systems [5].

The power management subsystem performed efficiently throughout the testing phase. The 2-cell Li-ion battery supplied stable power to all electronic components, while the integrated solar panel continuously recharged the battery through the buck converter during operation. This hybrid power configuration extended the operational duration and reduced reliance on external charging sources, making the system suitable for rural and off-grid farming environments [1], [8].

Overall, the experimental results demonstrate that the proposed system effectively integrates automation, renewable energy, and wireless control. The robot achieved reliable field navigation, precise seed placement, and sustainable operation, validating its applicability for small and medium-scale agricultural practices.

V. CONCLUSION AND FUTURE SCOPE

A. *Conclusion*

paper presented the design and development of a solar-powered, Bluetooth-controlled agricultural seed sowing robot intended to enhance precision, efficiency, and sustainability in farming operations. The proposed system effectively integrates an ESP32-WROOM microcontroller, DC motor–based mobility, a servo-driven seed dispensing mechanism, and a solar-assisted power supply into a compact and cost-effective robotic platform.

The four-wheel-drive configuration enabled stable and reliable navigation across agricultural terrain, while the servo-controlled seed dispensing mechanism ensured uniform seed placement with minimal wastage. Bluetooth-based wireless control offered a simple and user-friendly interface, allowing farmers to operate the system using a smartphone without requiring specialized technical knowledge. The incorporation of solar energy significantly reduced dependence on external power sources, making the system well suited for rural and off-grid agricultural environments [1], [8].

The experimental results demonstrate that the proposed robot can effectively reduce manual labor, improve seeding accuracy, and support environmentally sustainable agricultural practices. Overall, the system highlights the practical application of embedded systems, robotics, and renewable energy technologies in advancing precision agriculture solutions [9], [10].

B. *Future Scope*

The proposed system can be further enhanced by integrating advanced technologies to improve autonomy, scalability, and operational efficiency. Incorporation of GPS-based navigation can enable fully autonomous field operation with optimized path planning and reduced human intervention [5]. The addition of IoT connectivity and cloud-based monitoring can facilitate real-time tracking of field coverage, battery status, and seeding performance, thereby enabling data-driven agricultural decision-making.

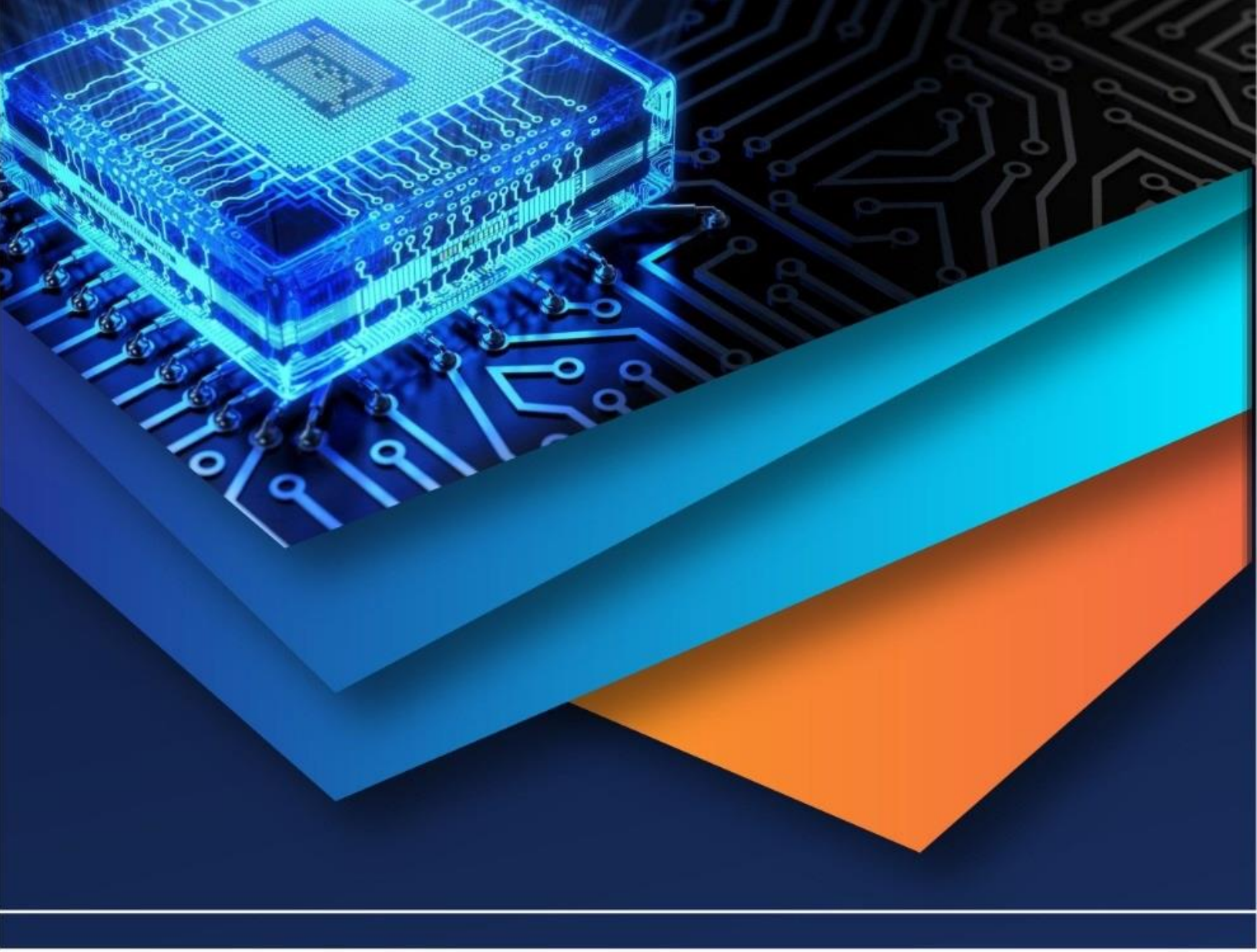
Future developments may also include multi-crop seeding mechanisms capable of handling different seed sizes and adjustable spacing to support diverse cropping requirements. Integrating soil moisture and environmental sensors can enable adaptive seed dispensing based on real-time field conditions, further improving crop yield and resource utilization [8]. Obstacle detection using ultrasonic or vision-based sensing techniques can enhance navigation safety and operational reliability. Additionally, upgrading the communication module to long-range wireless technologies such as LoRa or emerging 5G networks can extend operational range and improve scalability for larger agricultural fields [10].

©IJRASET: All Rights are Reserved | SJ Impact Factor 7.538 | ISRA Journal Impact Factor 7.894 |

REFERENCES

[1] G. J. P. Sinha, J. K. Singh, A. Kumar, and K. N. Agarwal, "Development of solar powered knapsack sprayer," Indian Journal of Agricultural Sciences, vol. 88, no. 4, pp. 590–595, 2022.
[2] M. Fuzafaraz, G. S. Jimi, S. Banan, M. R. Hasan, and A. Rahman, "Development of solar-powered sprayer," Fundamental and Applied Agriculture, vol. 6, no. 1, pp. 45–52, 2021.
[3] T. Singh and P. Verma, "Design and fabrication of solar powered multi-purpose sprayer," International Journal of Research in Engineering and Technology (IJRET), pp. 112–116, 2022.
[4] M. Ramesh, D. Kumar, and L. Priya, "Design of solar powered seed and fertilizer dispenser," International Journal of Innovative Research in Science, Engineering and Technology, vol. 13, no. 2, pp. 2341–2347, 2024.
[5] A. Sharma, R. Pandey, and K. Mehta, "Smart IoT-based solar spraying robot for precision agriculture," in Proc. IEEE Conf. on Smart Technologies for Agriculture, 2023, pp. 1–6.
[6] S. N. Sathapare, H. V. Pathan, S. S. Patil, and A. B. Mane, "Solar-powered seed spraying machine," Journal of Mechanical Robotics, vol. 10, no. 1, pp. 15–22, 2024.
[7] B. Patil, B. L. Keerthi, B. U. Shanmuk, and K. R. Kumar, "Multifunctional solar seed and atomizer sprayer," International Journal of Innovative Science, Engineering and Technology (IJISET), vol. 11, no. 4, pp. 89–94, 2023.
[8] B. Kumar, A. G. Shetty, A. Hegde, and D. Shetty, "A review on solar powered seed and fertilizer sprayer system," International Journal of Advanced Research in Engineering and Science Management (IJARESM), vol. 12, no. 3, pp. 102–108, 2024.
[9] I. Borase and P. Mythili, "Solar powered seed sowing machine," in Proc. 2020 Int. Conf. on Trends in Electronics and Informatics (ICOEI), Tirunelveli, India, 2020, pp. 196–201.
[10] S. Fanase, S. B. Suryawanshi, and A. Sutar, "Development of solar powered multipurpose agricultural robot," in Proc. 2020 Int. Conf. on Trends in Electronics and Informatics (ICOEI), 2020, pp. 196–201.
[11] M. W. Andure, R. Indani, N. Jadhav, B. Kawde, and R. Khamankar, "Design and fabrication of manual seed sowing machine with fertilizer," International Journal for Research in Applied Science and Engineering Technology, vol. 6, no. 3, pp. 274–281, 2018.
[12] K. R. Jadhav, A. S. Narote, P. U. Shelke, V. N. Alldawar, and A. S. Dhudhulde, "Design and fabrication of manually operated seed sowing machine," International Research Journal of Engineering and Technology (IRJET), vol. 6, no. 4, pp. 3006–3011, 2019.

©IJRASET: All Rights are Reserved | SJ Impact Factor 7.538 | ISRA Journal Impact Factor 7.894 |



10.22214/IJRASET

45.98

IMPACT FACTOR: 7.129

IMPACT FACTOR: 7.429

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Call : 08813907089 (24*7 Support on Whatsapp)