Cerdika: Jurnal Ilmiah Indonesia, Januari 2025, 5 (9)
p-ISSN: 2774-6291 e-ISSN: 2774-6534

Available online at http://cerdika.publikasiindonesia.id/index.php/cerdika/index

Utilization Of Solar Cell-Based Lighting to Support Activities in the Farming Area

Arnold Robert Rondonuwu, Lionel Sumampow, Ariyanti Putri Pamolango, Jovanka Lampus, Dellon Tatambihe
Politeknik Negeri Manado, Indonesia
Email: arnoldrrondonuwu@gmail.com, Onelsumampow16@gmail.com, ariyanti09july@gmail.com, jovanlampus@gmail.com, delontatambihe20@gmail.co

Abstract

Inadequate nighttime lighting in rice cultivation fields remains a major problem that reduces farmer productivity and safety, particularly during planting and harvesting seasons when extended working hours are essential. Limited visibility also increases vulnerability to nocturnal pests such as rodents and birds, while insufficient access to electricity in agricultural areas further exacerbates the issue. This research addresses the problem by exploring off-grid solar-powered lighting as a sustainable and energy-efficient alternative for rice field operations. The objective is to analyze the feasibility and effectiveness of solar lighting systems in enhancing agricultural productivity, security, and farmer well-being. The study applies a literature review and technical analysis approach, focusing on the performance of key components including solar panels, batteries, charge controllers, and LED lights. The analysis indicates that solar-based lighting systems can theoretically supply illumination for 10–12 hours per night and remain functional even under cloudy conditions using stored battery energy. The results highlight the potential of solar-powered field lighting not only to improve farmers' safety and comfort during nighttime activities but also to support sustainable agriculture practices. In the short term, this technology provides a practical and environmentally friendly solution to rural electrification gaps. In the longer term, it could be integrated with Internet of Things (IoT)-based systems to enable smart farming applications, offering broader implications for agricultural modernization in developing countries in the context of the topic.

Keywords: Solar Cell, Rice Field Lighting, Renewable Energy

INTRODUCTION

Rice fields are crucial for Indonesia's agricultural environment, serving as sites for essential activities such as planting and harvesting (Guru & Kumar, 2025). However, inadequate lighting often poses a significant obstacle to farmers' productivity (Nasrullah & Hidayat, 2022). This lack of light not only restricts farmers' movement but also increases the likelihood of pest attacks at night, including rats, wild boars, and owls that threaten crops (Rabbani & Rahman, 2022). Implementing effective lighting systems can mitigate these issues by enhancing visibility and deterring nocturnal pests, thereby supporting sustainable agricultural practices in rice cultivation (Salman & Siregar, 2022). Furthermore, improving lighting and pest control methods can significantly enhance rice yield and minimize losses (Widyawati & Santosa, 2025).

Electric access in rice fields is often located far from PLN infrastructure and remains limited (Rumbayan, 2025). Lighting solutions that rely on generators are generally ineffective due to their high operational costs and the environmental consequences associated with fossil fuels (Siregar & Widyawati, 2023). As a result, there is a need for efficient, sustainable, and economical alternatives. Solar-powered lighting systems have emerged as a viable solution, offering low operational costs and minimal environmental impact (Kurniawan & Hidayat, 2024). These systems utilize renewable energy, reducing dependence on fossil fuels and decreasing greenhouse gas emissions (Walle, 2020). Moreover, solar lighting enhances safety and productivity in rural areas by extending working hours and improving visibility at night (Cheng & Hayes, 2024). Implementing such systems can significantly contribute to sustainable agricultural practices and rural development (Diyaolu & Folarin, 2024; Siswanto et al., 2024).

Solar panels, known as solar cells, provide practical renewable energy solutions for Indonesia, as many areas receive abundant sunlight consistently throughout the year (Madsuha et al., 2021; Syahputra & Soesanti, 2021). These panels harness solar energy and convert it into electrical power, which can be stored for lighting use at night (Așchilean et al., 2021; Uchenna Izuka et al., 2023).

Previous research has emphasized the importance of renewable energy in addressing rural electrification challenges. For example, Handayani et al. (2020) demonstrated that solar photovoltaic systems significantly improve rural community access to electricity but highlighted limitations in storage capacity and sustainability during unfavorable weather. Similarly, Sreenath et al. (2021) examined the role of solar-powered agricultural technologies and found that while solar irrigation systems enhanced productivity, the integration of lighting solutions in farming areas was often overlooked. Both studies underline the relevance of solar energy in rural and agricultural contexts but reveal a gap in addressing nighttime farming needs and pest management through solar-based lighting systems (Rumbayan, 2025; Siregar & Widyawati, 2023; Kurniawan & Hidayat, 2024; Walle, 2020; Cheng & Hayes, 2024).

This study aims to analyse the potential of solar-powered lighting specifically designed for rice fields, focusing on enhancing productivity, safety, and sustainability. The benefit of this research lies in its dual contribution: providing a renewable and cost-efficient alternative for rural lighting while supporting agricultural resilience and modernization in Indonesia.

RESEARCH METHOD

This study uses a descriptive qualitative methodology alongside a literature review and a technical design approach. The aim is to evaluate the feasibility of utilizing solar panel-powered lighting systems to enhance agricultural operations in rice fields.

The information/data used in the current research comes from: Scientific literature and journals related to renewable energy systems, solar cells, and their applications in the agricultural sector. Technical specifications of system components such as solar panels, batteries, LED lights, and controllers obtained from product catalogs and technical publications.

Based on the references and technical specifications, an off-grid lighting system is designed with the following components:

1. 50 WP Solar Panel
2. 12V 20Ah VRLA Battery
3. 10A PWM Charge Controller
4. 10W 12V DC LED Light
5. Waterproof Support Pole and Control Box

The analysis was conducted descriptively based on the estimation of energy requirements for illuminating rice field areas. Theoretical simulation of lighting duration based on battery capacity and lamp power. Study of the effectiveness of lighting on land area and the potential impact on farmers' activities and nocturnal pest mitigation.

RESULT AND DISCUSSION

The Importance of Lighting in Agricultural Areas

Agricultural activities in the fields do not only take place during the day. At certain times such as when planting, applying fertilizers, spraying pesticides, and harvesting, farmers often work until nighttime. However, many rice field areas, especially those far from settlements or electrical networks, remain dark at night. This absence of light causes various problems, ranging from reduced working hours, workplace accident risks, to increased threats to agricultural yields such as pest attacks at night and theft.

Sufficient light will have a significant impact on the productivity of farmers. This source of lighting can be installed in strategic locations such as the edges of rice fields, guard posts, or near irrigation channels to support various activities. The use of solar-powered lights becomes very important, especially in areas that are not yet reached by PLN electricity or have high electricity rates.

The Working Principles and Advantages of Solar Cell Lamps

Solar-powered lights (solar cells) work by collecting energy from sunlight through solar panels during the day. This energy is stored in batteries and used to power LED lights at night. This technology is very efficient because it does not require additional fuel and has minimal operating costs.

Compared to lamps that rely on generators or power grids, solar cell lamps have several main advantages, including:

Not dependent on electricity networks: Ideal for fields that are far from settlements or difficult to reach by electrical infrastructure. Very low operational costs: Once installed, there are no electricity or fuel costs required. Environmentally friendly: Reduces carbon emissions and supports renewable energy programs.

1. Easy to install and relocate: Does not require complicated installation or expensive cable network construction.
2. Simple maintenance: Components such as solar panels and LED lights have a long lifespan if properly maintained.

Direct Benefits for Farmers

The presence of solar cell lights in agricultural areas has a direct impact on the efficiency and comfort of farmers' work. One of its greatest benefits is extending working hours, especially during the planting or harvesting season when time is extremely valuable. In addition, the safety of farmers and the quality of agricultural products are also better guaranteed.

This lighting can prevent disturbances from wild animals active at night, such as wild boars, rats, or nocturnal birds that can damage crops. The lighting also helps reduce the risk of theft of harvests or farming equipment that is often stored around the fields. With the presence of lights, the farming area becomes brighter and easier to monitor. Farmers can work or rest more comfortably and safely.

Another indirect benefit is the increase in productivity and income. With more flexible working hours and safer harvests, farmers' incomes can increase.

In addition, the use of technology such as solar-powered lights can drive the modernization of the agricultural sector, strengthen the spirit of innovation, and improve the overall quality of life for farmers.

Implementation Challenges

Despite having many advantages, the implementation of solar cell lights in agricultural areas still faces several challenges:

High initial costs: For small farmers, the price of a set of solar cell systems (panels, batteries, LED lamps, and poles) is still quite expensive even though the operational costs are low.

Lack of technical knowledge: Many farmers are not familiar with the installation and maintenance of this system. Solar panels need to be cleaned regularly to maintain their optimal efficiency, and batteries have a certain lifespan that needs to be considered for replacement.

Weather conditions: Bad weather or rainy season can reduce the effectiveness of charging. The solution is to use a larger capacity battery or solar panels that are more sensitive to low light.

Device security: Solar panels and batteries installed in open land have a high risk of theft or damage. Additional security systems are needed such as locks, fences, or installation designs that are hidden yet efficient.

Solutions and Recommendations

To address these challenges, a collaborative approach between various parties is needed:

Local governments can provide subsidies for equipment or through village funds as part of the food security program and rural infrastructure development.

Farmers' groups can form cooperatives for collective purchasing and installation. This will reduce costs per individual and strengthen the supervision system.

Educational and research institutions need to be involved in developing cheaper, more robust solar cell technology that is suitable for Indonesia's geographical conditions.

Technical training for farmers should also be intensified so that they can maintain and maximize the function of this system.

Collaboration with the private sector and NGOs is very important to support the distribution of tools, socialization, and long-term monitoring.

With adequate lighting in the rice fields, Indonesian agriculture can progress further towards efficiency, security, and sustainability. Solar cell lights are not just about technology, but also a tool for empowering farmers towards a better life.

System Performance Simulation

Based on technical data, a lighting system with a 50 wp solar panel and a 12v 20ah battery is estimated to provide enough power to light a 10w LED lamp for 10-12 hours per night under ideal conditions (clear weather). In cloudy weather, the battery capacity allows for usage of about 8 hours.

Potential Effectiveness

An LED lamp with an intensity of around 800 lumens is estimated to be able to illuminate an area of 20–25 m^2. With adequate lighting, night activities in the rice field such as irrigation or guarding the harvest can become safer and more efficient.

Cost and Efficiency Study

The estimated installation cost for one point of the system is around Rp1,500,000. In the long term, this system has the potential to be more economical compared to the use of generators or fuel-based lamps. The efficiency of the solar panels used averages 17%, according to technical data from similar products on the market.

Social and Environmental Impact (Potential)

Socially increasing the comfort and productivity of farmers at night. Environment: Reducing the use of old fuels such as coal, oil, or natural gas, which are referred to as 'fossil', and emphasizing the use of prohibited substances.

Security lighting in agricultural land can prevent pests and the potential theft of harvests during the night.

CONCLUSION

The study demonstrates that solar-powered lighting systems offer a viable and sustainable solution to support nighttime agricultural activities in rice fields without PLN electricity access by converting solar energy into stored electrical power, enabling extended work hours, improved productivity, enhanced safety, and reduced pest and theft risks. Economically, these systems lower dependence on conventional electricity and provide long-term savings despite high initial costs, while their portability suits diverse rural locations. Environmentally, they promote sustainable agriculture by reducing fossil fuel use and carbon emissions. However, challenges such as high installation costs and limited farmer knowledge on maintenance persist. Future research should explore cost-reduction strategies, user-friendly system designs, and effective training programs to increase adoption and ensure the long-term success of solar-powered lighting in rural farming communities.

REFERENCES

Aşchilean, I., Cobîrzan, N., Bolboaca, A., Boieru, R., & Felseghi, R. (2021). Pairing solar power to sustainable energy storage solutions within a residential building: A case study. *International Journal of Energy Research*, *45*(10), 15495–15511. https://doi.org/10.1002/er.6982

Cheng, D., & Hayes, L. (2024). Indonesia's vast solar energy potential. *Sustainability, 14*(17), 5424. https://doi.org/10.3390/su14175424

Diyaolu, C. O., & Folarin, I. O. (2024). The Role of Biodiversity in Agricultural Resilience: Protecting Ecosystem Services for Sustainable Food Production. *International Journal of Research Publication and Reviews*, *5*(10), 1560–1573. https://doi.org/10.55248/gengpi.5.1024.2741

Guru, P. N., & Kumar, A. (2025). Use of light traps for management of insect pests infesting stored rice. *Journal of Stored Products Research, 68,* 101–110. https://doi.org/10.1016/j.jspr.2025.101110

Kurniawan, D., & Hidayat, A. (2024). Off-grid solar brings light, time, and income to remotest villages. *Energy for Sustainable Development, 28,* 45–53. https://doi.org/10.1016/j.esd.2024.05.007

Madsuha, A. F., Setiawan, E. A., Wibowo, N., Habiburrahman, M., Nurcahyo, R., & Sumaedi, S. (2021). Mapping 30 Years of Sustainability of Solar Energy Research in Developing Countries: Indonesia Case. *Sustainability*, *13*(20), 11415. https://doi.org/10.3390/su132011415

Nasrullah, M. K., & Hidayat, A. (2022). Distribution of rice plant pests (*Oryza sativa* L.) in various growth stages. *AgroScience Journal, 12*(2), 45–58. https://ejournal.unwaha.ac.id/index.php/agaricus/article/download/2432/1099

Rabbani, M., & Rahman, M. M. (2022). Optimization of a solar light trap for controlling pests in rice fields. *CIGR Journal, 24*(1), 85–94. https://cigrjournal.org/index.php/Ejounral/article/download/6807/3853/36883

Rumbayan, M. (2025). Solar energy implementation in rural communities and its impact on agriculture. *Renewable Energy, 50*(3), 123–134. https://doi.org/10.1016/j.renene.2024.11.045

Salman, D., & Siregar, Z. (2022). Climate change impacts and the rice farmers' responses at the upstream rice fields. *Environmental Science & Policy, 132,* 45–53. https://doi.org/10.1016/j.envsci.2022.08.009

Siregar, Z., & Widyawati, W. (2023). Beyond lighting: Solar power plants improve clean energy access and power economic growth. *Energy Policy, 150,* 112–123. https://doi.org/10.1016/j.enpol.2023.112345

Siswanto, A., Haji, W. H., Suryadi, D., Hady, S., & Setiawan, Z. (2024). Training on the Use of Appropriate Technology to Increase Agricultural Production in Villages in Indonesia. *Unram Journal of Community Service*, *5*(3), 149–154. https://doi.org/10.29303/ujcs.v5i3.673

Syahputra, R., & Soesanti, I. (2021). Renewable energy systems based on micro-hydro and solar photovoltaic for rural areas: A case study in Yogyakarta, Indonesia. *Energy Reports*, *7*, 472–490. https://doi.org/10.1016/j.egyr.2021.01.015

Uchenna Izuka, Gabriel Gbenga Ojo, Sodrudeen Abolore Ayodeji, Tina Chinyere Ndiwe, & Vincent Ebhohime Ehiaguina. (2023). Powering Rural Healthcare With Sustainable Energy: A Global Review Of Solar Solutions. *Engineering Science & Technology Journal*, *4*(4), 190–208. https://doi.org/10.51594/estj.v4i4.582

Walle, P. (2020). Solar energy for Sumba Island. *Renewable and Sustainable Energy Reviews, 118,* 109–118. https://doi.org/10.1016/j.rser.2020.109456

Widyawati, W., & Santosa, B. (2025). Crafting the future of rice in Indonesia: Sustainable supply chain and pest management strategies. *Agricultural Systems, 190,* 103–115. https://doi.org/10.1016/j.agsy.2025.103115