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Design of an Automatic Mouse Trap Powered by Solar Panels for Agricultural Land

Irfan Rifa'i, Muhamad Riyad Ariwibowo*
Universitas Swadaya Gunung Jati, Indonesia
Email: irfan12220010@ugj.ac.id, riyad_ariwibowo@ugj.ac.id*

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Abstract
Rice production plays an important role in supporting global food security. However, agricultural productivity is continuously threatened by pest infestations, particularly rodents, which cause significant crop losses. Conventional rodent control methods commonly used by farmers still face several limitations, including low efficiency, environmental risks, safety concerns, and dependence on external electricity sources. This study aims to design and evaluate an automatic mouse trap system powered by solar panels as an environmentally friendly and energy-independent solution for agricultural land. The research employed an experimental method using a Research and Development (R&D) approach that involved system design, construction, implementation, testing, and quantitative analysis. The developed system consists of a 30 Wp solar panel, a solar charge controller (SCC), a 12 V, 35 Ah battery, an inverter, a capacitor, and an automatic electric-shock mechanism. The test results showed that the solar-powered system was able to operate the automatic mouse trap without requiring electricity from the PLN grid. During eight days of testing, the solar panels generated electrical power ranging from 48 W to 78 W, while maintaining a stable output voltage between 12 and 13 V, indicating sufficient energy availability to support continuous system operation. These findings demonstrate that integrating solar energy can improve the efficiency, sustainability, and energy independence of agricultural pest control technology. In conclusion, the developed automatic mouse trap represents a promising renewable energy-based solution for modern agriculture, particularly in rural areas with limited access to conventional electrical infrastructure.

INTRODUCTION

Rice is one of the world's most important staple crops and plays a critical role in supporting global food security, serving as the primary food source for approximately 21% of the global population (Mohidem et al., 2022). However, efforts to increase rice production continue to face numerous challenges, including pest infestations, plant diseases, changing climatic conditions, and the increasing energy demands associated with modern agricultural systems.

Among agricultural pests, rodents are one of the primary causes of crop damage and can significantly reduce rice yields (Htwe et al., 2019). Therefore, effective and efficient rodent control methods are essential for maintaining agricultural productivity and ensuring the sustainability of food production.

Advances in renewable energy technologies have created promising opportunities for developing modern agricultural systems, particularly through the utilization of solar photovoltaic (PV) systems (Pandiyan et al., 2022). Solar energy is recognized as a clean, sustainable, and readily available energy source, making it well suited for supporting automated agricultural technologies.

The use of solar energy to power automatic mouse trap systems can reduce dependence on conventional energy sources while lowering operational costs. Moreover, this approach is particularly suitable for rice fields located far from the PLN electricity grid, enabling the equipment to operate more independently, effectively, and efficiently (Saha, 2025). To ensure reliable long-term operation, the automatic mouse trap system requires efficient energy management. Implementing an intelligent power management system can optimize energy allocation based on battery capacity, solar irradiance, and the power requirements of each system component.

Damage to rice plants caused by rodent infestations generally follows a distinctive pattern, beginning in the center of the field and gradually spreading toward the field boundaries. Under severe infestation conditions, most of the rice plants may be destroyed, leaving only one or two rows of rice along the edges of the field.

Rodent trapping methods commonly used by farmers are still dominated by manual systems, some of which present safety risks to users. Traditional traps generally have limited capture capacity, often catching only a few rodents—or even just one—in a single night. In addition to mechanical traps, some farmers use poison-laced bait to control rodent populations. However, this method often creates additional problems because poisoned rodents may die in inaccessible locations, causing unpleasant odors as the carcasses decompose in or around the rice fields. Furthermore, some farmers use high-voltage electricity supplied by the PLN grid, connecting live wires around rice fields and trap locations to control rodent pests. This practice poses significant safety hazards to humans and animals.

The increasing demand for sustainable agricultural practices has encouraged the adoption of renewable energy technologies, particularly solar photovoltaic (PV) systems. Solar energy has become one of the most promising renewable energy sources because it is environmentally friendly, widely available, and well suited for decentralized applications in rural areas (Minaei et al., 2021). According to the International Renewable Energy Agency (IRENA, 2023), solar photovoltaic technology continues to experience rapid global expansion due to declining installation costs and its ability to provide electricity access in areas with limited grid infrastructure. In agricultural environments, solar energy can support automated equipment by providing an independent power supply without relying on conventional electricity networks. This creates opportunities to develop agricultural technologies that integrate renewable energy with automation to improve operational efficiency and sustainability.

Several previous studies have investigated technology-based solutions for agricultural pest management, reflecting a broader shift toward IoT-enabled precision pest management platforms (Ahmed et al., 2024). Arifandi et al. (2021) developed a Raspberry Pi-based pest control system for rice fields that integrated monitoring and automated control mechanisms. Similarly, Mujab et al. (2020) designed an ultrasonic pest repellent system as an alternative approach for reducing agricultural pest problems, a direction consistent with recent IoT-based crop pest detection frameworks (Azfar et al., 2023). Amsal et al. (2024) further developed an Internet of Things (IoT)-based automatic rat trap system, demonstrating the potential of digital technologies to improve pest management effectiveness, consistent with wider trends in IoT-based smart agricultural pest-detection systems (Chen et al., 2020). In addition, Divine et al. (2025) introduced an IoT-enabled, solar-powered pest control system that utilized renewable energy for agricultural applications. Collectively, these studies demonstrate that automation, IoT, and renewable energy technologies have considerable potential to improve agricultural pest control systems.

Although previous studies have made valuable contributions to agricultural automation, several limitations remain, as recent systematic reviews of precision agriculture technologies indicate (Getahun et al., 2024). Most existing pest control technologies focus primarily on control mechanisms, such as ultrasonic devices, IoT monitoring, or microcontroller-based automation, while comparatively little attention has been given to ensuring continuous and independent energy availability under field conditions. Many agricultural areas, particularly remote rice fields, still have limited access to reliable electrical infrastructure. Consequently, pest control devices that depend on conventional electricity sources may experience operational constraints. Integrating solar photovoltaic systems with automatic pest control mechanisms therefore remains an important research opportunity for developing autonomous agricultural equipment capable of operating independently in remote locations.

The urgency of this research is reinforced by the growing demand for agricultural technologies that are efficient, environmentally sustainable, and applicable under real field conditions (Rumbayan et al., 2025). Farmers require pest control solutions that not only improve effectiveness but also reduce operational costs while minimizing environmental impacts. Using solar energy as the primary power source reduces dependence on fossil fuels and conventional electricity networks. Furthermore, an automated system can reduce farmers' workload by enabling continuous pest control without frequent manual intervention. Therefore, developing a solar-powered automatic mouse trap represents an important step toward advancing precision agriculture and sustainable farming practices.

The novelty of this research lies in integrating a solar photovoltaic energy system with an automatic mouse trap equipped with an intelligent power management system. Unlike previous studies that primarily emphasized pest detection, IoT monitoring, or mechanical trapping mechanisms, this research focuses on developing a self-sufficient energy system capable of supporting automatic pest control operations in agricultural areas without dependence on the PLN electricity grid, in line with broader efforts to electrify remote agricultural areas using renewable energy sources (Karamov et al., 2022). The proposed system integrates solar panels, a solar charge controller (SCC), battery storage, an inverter, capacitors, and an automatic electric-shock mechanism into a single agricultural technology solution. Through this integrated approach, the research contributes to the development of autonomous agricultural equipment powered by renewable energy.

The purpose of this research is to design and evaluate an automatic mouse trap system powered by solar panels for agricultural applications, building on recent Indonesian efforts to apply solar power generation systems in rice-field settings (Prasetya, 2025). Specifically, the study aims to evaluate the ability of solar photovoltaic technology to supply electrical energy for automatic pest control operations, assess system performance under field conditions, analyze energy utilization efficiency, and determine the stability of battery charging and power management processes. The research employs an experimental method using a Research and Development (R&D) approach involving system design, construction, implementation, testing, and quantitative evaluation. The study was conducted in rice fields located in Dukupuntang District, Cirebon Regency, West Java, where frequent rodent infestations and abundant solar energy provide suitable conditions for system testing.

The contribution of this research is both technological and practical. From a technological perspective, this study contributes to the advancement of renewable-energy-based agricultural automation by demonstrating the feasibility of solar-powered rodent control equipment. From a practical perspective, the developed system provides farmers with a safer, more efficient, and less electricity-dependent method of rodent management, consistent with animal welfare assessments indicating that electrocution-based traps induce comparatively less suffering than several conventional rodent-control methods (De Ruyver et al., 2023). The implementation of this technology may support the modernization of rural agriculture by enabling farmers to utilize renewable energy resources to improve productivity while reducing operational challenges.

The benefits of this research extend to farmers, agricultural technology developers, and future researchers. For farmers, the developed system offers a sustainable solution for controlling rodent populations while reducing dependence on conventional energy sources and labor-intensive pest management methods. For agricultural technology developers, this research provides a foundation for further innovation involving renewable energy, automation, and intelligent control systems in agriculture. For future researchers, this study offers opportunities to enhance the system through the integration of advanced technologies such as the Internet of Things (IoT), artificial intelligence-based monitoring, and adaptive energy management systems. Ultimately, this research contributes to the broader goal of developing sustainable agricultural systems capable of addressing global food security challenges through technological innovation.

METHOD

This study employed an experimental Research and Development (R&D) approach. The research consisted of system design, construction, implementation, and testing of an automatic mouse trap powered by a solar photovoltaic (PV) system with an intelligent power management mechanism. The experimental procedures were conducted to evaluate the system's performance in utilizing solar-generated electrical energy, measure power utilization efficiency, assess battery charging stability, and determine the system's ability to operate the automatic mouse trap under actual field conditions.

Study Areas and Datasets

The research was carried out in a rice field area in Dukupuntang District, Cirebon Regency, West Java. The location was chosen because it has a fairly high intensity of rat pest attacks and has a good potential for sunlight intensity for the implementation of the solar power system.

The research period was carried out for 3 months, starting from March, April to April 2026, including the stage of designing tools, creating systems, testing, and data analysis.

Solar Power Plant Equipment Design

The system design is carried out by combining several main components, namely a solar panel with a capacity of 30 Wp, *a Solar Charge Controller* (SCC), a 12V 35Ah battery, a capacitor, and an automatic electric shock mechanism. The electrical energy generated by the solar panels is used to charge the battery while meeting the energy needs of all components in the system.

The design of the solar power system is simple as an energy source in automatic rat traps. The system consists of a 30 WP solar panel, SCC, a 12 V 35 Ah battery, a volt meter, a DC to AC inverter, and an electric rat trap as a load, a configuration consistent with typical off-grid photovoltaic battery-charging architectures reported in the literature (Apeh et al., 2021).

Data Analysis Techniques

The data analysis technique in this study was carried out quantitatively based on the data from the measurement and testing of the Solar Power Plant (PLTS) system applied to automatic rat traps with intelligent control-based power management. The data that has been obtained is then analyzed to evaluate the performance of the solar panels, the stability of the energy storage system, the level of power use efficiency, and the system's ability to carry out rat trap operations automatically. to determine the level of effectiveness, stability, and efficiency of the system in operating on agricultural land.

Electrical Power Calculation

The calculation of electrical power is carried out to find out the amount of electrical energy produced by the solar panels and used by the system load. The equations used are:

$$P = V.I \text{..........................(3.1)}$$

Description :

P = Power (Watts)

V = Voltage (Volts)

I = Arus (Ampere)

The greater the value of voltage and current produced by the solar panel, the greater the electrical power obtained.

Battery Charging Analysis

The analysis of the battery charging process was carried out to evaluate the ability of the solar panel to deliver electrical energy to the battery through *the Solar Charge Controller* (SCC). The parameters observed in this test include the battery voltage, charging current, as well as the duration of charging the battery at different levels of sunlight intensity received by the solar panel, following charge-controller evaluation approaches established in comparative studies of solar PV charge-controller techniques (Lokesh Reddy et al., 2017).

Energy Utilization Efficiency Analysis

Data Efficiency analysis was conducted to evaluate the level of effectiveness of the use of electrical energy generated by solar panels in meeting the power needs of the automatic rat trap system. The efficiency level of the system is determined through a comparison between the amount of energy generated by the solar panels with the electrical energy consumed by the load during the operational process.

RESULTS AND DISCUSSION

Based on the design results that have been carried out, the automatic rat trap system based on the Solar Power Plant (PLTS) has been successfully realized by utilizing solar energy as the main energy source. The system consists of a 30 Wp solar panel, *Solar Charge Controller* (SCC), 12V 35Ah battery, DC to AC inverter, digital voltmeter, capacitor, and automatic rat trap unit. The DC electrical energy generated by the solar panels is regulated through the SCC for the battery charging process, then stored in the battery as an energy storage medium. Furthermore, the inverter functions to convert direct current (DC) into alternating current (AC), while capacitors are used to store the temporary energy required in the rat trap electric shock system. Based on the test results, all system components can operate properly and integrate with each other, so that the system is able to run rat traps automatically without requiring electricity supply from the PLN network.

Figure 1 Solar PV Equipment Design Results

Based on the drawing of the tool design above, the Solar Power Plant (PLTS) system has been successfully applied to automatic rat traps in rice fields. The design of the tool consists of a solar panel installed on the top of the pole as the main energy source, a box panel as a place for the control system and electrical circuit, and a 12V 35Ah battery installed under the box panel as a medium for storing electrical energy.

The electrical energy generated by the solar panels is harnessed to charge the battery through a charging control system, then the stored energy is used to operate the automatic rat trap. The system is designed with a strong construction and installed directly in the rice field area so that it can operate independently without depending on the electricity supply from the PLN network. In addition, the use of solar energy in this system provides advantages in the form of more efficient, environmentally friendly, and suitable energy use for application in agricultural areas.

How the Solar Power System Works

The working principle of the solar power system in the image above begins with a solar panel that absorbs sunlight energy and converts it into direct current (DC) electrical energy. The electrical energy produced is then channeled to *the Solar Charge Controller* (SCC) which functions to regulate the amount of voltage and current so that the battery charging process can take place stably, safely, and efficiently. Furthermore, the electrical energy is stored in the battery as the main power source for the system.

The DC energy stored in the battery is then fed to the inverter to be converted into alternating current (AC). After the conversion process, the capacitor is used as a temporary energy store which functions to support the release of electrical energy in the trap system. The AC current that has been generated is then flowed to the rat trap. When the rat touches the trap, an electric current will flow through the rat's body, causing an electric shock. With this mechanism, the rat trap system can operate automatically by utilizing energy from solar panels without requiring electricity supply from the PLN network.

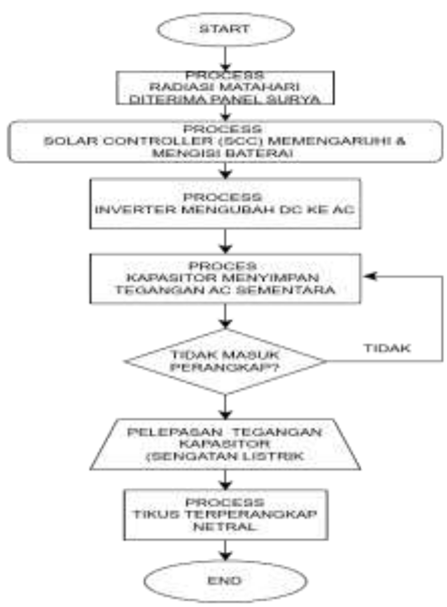

Figure 2 Energy conversion process method in solar PV system

The trap system works automatically by utilizing batteries, inverters, and capacitors to generate electric shock in the rat trap. The use of microcontrollers makes the system work more stable and efficient in controlling the working process of the tool.

Average test score over 8 days of trial

Based on Table 4.1, the data from the test results carried out for 8 days in the period of 07.00–16.00 WIB, it can be seen that the current, voltage, power, and temperature values of the solar panels have changed which are influenced by weather conditions and the intensity of sunlight received by the panel. This test aims to determine the ability of solar panels to supply electrical energy to an automatic rat trap system.

Table 1 Average results over 8 days of experiment

Day to	Measurement Time	Current (A)	Tegangan (V)	Power (W)	Panel Temperature (°C)
Wed 1	07.00-16.00	5	12	60	38(°C)
Wed 2	07.00-16.00	4	12	48	36(°C)
Wed 3	07.00-16.00	5	12	60	40(°C)
Wed 4	07.00-16.00	6	13	78	42(°C)
Wed 5	07.00-16.00	5	13	65	41(°C)
Wed 6	07.00-16.00	5	13	65	43(°C)
Wed 7	07.00-16.00	6	13	78	42(°C)
Wed 8	07.00-16.00	6	13	78	45(°C)

On the first day, the solar panels produce a current of 5 A and a voltage of 12 V, so the power generated reaches 60 W with a panel temperature of 38°C. This value shows that the solar panels are able to work well in fairly favorable weather conditions.

On the second day, there was a decrease in the performance of the solar panel which was characterized by a drop in current to 4 A while the voltage remained at 12 V. As a result, the power generated dropped to 48 W, which was the lowest value during the test. In addition, the temperature of the panels also decreased to 36°C. This condition indicates that the intensity of the sun's rayage on the second day is lower than on the other day, likely due to cloudy or cloudy weather.

From the third day, the current again increases to 5 A with a fixed voltage of 12 V, so that the power generated rises to 60 W. The temperature of the panel also increases to 40°C. This shows an increase in the intensity of sunlight received by the panel compared to the previous day.

The most significant performance improvement occurred on the fourth day, where the current reached 6 A and the voltage increased to 13 V. This condition resulted in a power of 78 W, which was the highest power during the test. The temperature of the panel was recorded at 42°C, indicating that the panel received high enough exposure to sunlight to be able to produce greater electrical energy.

On the fifth day, the current drops slightly to 5 A but the voltage remains 13 V, so the power generated becomes 65 W with a panel temperature of 41°C. This value is still relatively good and shows that the solar panels are still able to produce enough energy to support the operation of the system.

On the sixth day, the current and voltage values did not change compared to the fifth day, which were 5 A and 13 V, so the power remained at 65 W. However, the panel temperature increased to 43°C. Even though the temperature increases, the power generated remains stable because the irradiation conditions are relatively similar.

On the seventh day, the current again increases to 6 A with a fixed voltage of 13 V, so that the power generated again reaches 78 W. The panel temperature is at 42°C. These results show that the solar panels are again receiving optimal sunlight intensity.

Furthermore, on the eighth day, the current and voltage remained at the highest values, which were 6 A and 13 V, so that the power generated remained at 78 W. The panel temperature reached 45°C, which was the highest temperature during the test. The high temperature of the panel indicates that the sun's irradiation on that day is very good and lasts for a considerable time.

Overall, the data shows that the electrical power produced by solar panels is greatly influenced by the amount of current and voltage generated, which in turn are strongly shaped by environmental factors such as solar irradiance and ambient temperature (Bamisile et al., 2025). As the current and voltage increase, the power generated also increases. The highest power value of 78 W was obtained on the 4th, 7th, and 8th days, while the lowest power of 48 W occurred on the 2nd day. The temperature of the panels during the test was in the range of 36°C–45°C, which indicates that the solar panels are working in fairly good solar radiation conditions. Based on these results, it can be concluded that the solar panel system is able to provide stable and adequate electrical energy to support the operation of automatic rat traps on agricultural land.

Graph of Voltage and Current to Electrical Power

Based on the Average Test Day Data graph, it can be seen that the current, voltage, power, and temperature values of the solar panels changed during the eight days of testing. The voltage tends to be stable in the range of 12–13 Volts, indicating that the energy storage and distribution system is working well. The current value was also relatively stable with a slight increase on several days of testing.

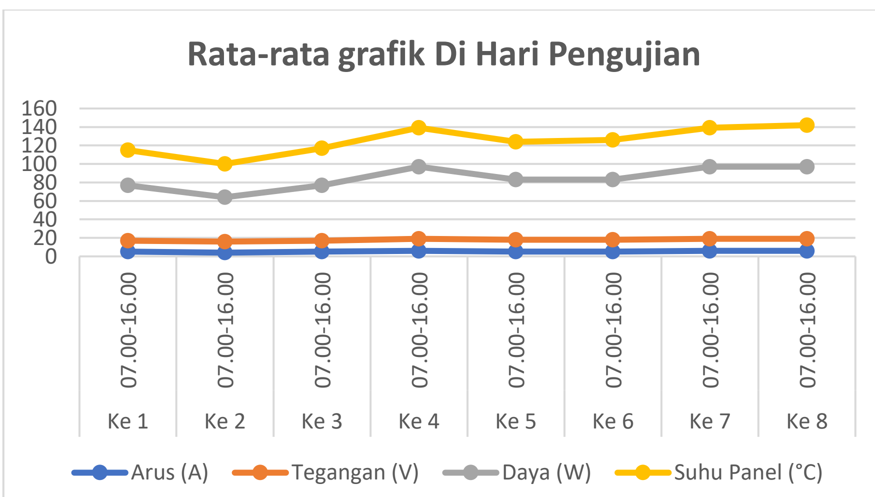

Figure 2 Current Voltage to Electrical Power

The power produced by solar panels fluctuates following changes in current. The lowest power occurred on the 2nd day, then increased and reached the highest value on the 4th day, after which it briefly decreased on the 5th and 6th days before increasing again on the 7th and 8th days.

This shows that the intensity of sunlight received by solar panels is not always the same every day, a pattern that has similarly been observed to affect inverter output performance in grid-connected photovoltaic systems under varying climate conditions (Bhavani et al., 2023).

The temperature of the solar panel also changes during the test. The lowest temperature occurred on day 2, while the highest temperature was recorded on day 8. In general, an increase in panel temperature is followed by an increase in power produced, indicating that the panel receives greater sun exposure on those days, consistent with prior findings on the environmental impacts of temperature and irradiance on photovoltaic system performance (Mustafa et al., 2020).

Overall, the test results showed that the solar panel system was able to work well and generate relatively stable power during the test period. The fluctuations that occur are influenced by environmental conditions, especially the intensity of solar radiation and the temperature of the panel at the time of measurement.

CONCLUSION

The research concluded that the automatic mouse trap powered by solar panels was successfully designed and implemented as an autonomous agricultural technology for controlling rodent pests in rice fields. The integration of a 30 Wp solar panel, a solar charge controller (SCC), a 12 V, 35 Ah battery, an inverter, a capacitor, and an automatic electric-shock mechanism enabled the system to operate independently of the PLN electricity grid. The experimental results demonstrated that the solar photovoltaic (PV) system generated a stable electrical power supply to support automatic trap operation, with power output influenced by solar irradiance and environmental conditions. During the eight-day testing period, the solar panel generated power ranging from 48 W to 78 W while maintaining a stable voltage between 12 and 13 V, indicating that the system provided sufficient energy for agricultural applications. Overall, the developed solar-powered automatic mouse trap represents an effective, environmentally friendly, and energy-independent alternative for improving rodent pest control in agricultural areas, particularly in locations with limited access to conventional electricity.

For future research, further development is recommended through the integration of advanced technologies such as the Internet of Things (IoT) for real-time monitoring, artificial intelligence (AI) for rodent detection and prediction, and remote-control capabilities to improve operational efficiency and data acquisition. Future studies should also evaluate system performance over extended operating periods and under a wider range of environmental conditions to assess durability, energy efficiency, and scalability. In addition, improvements in energy management, battery optimization, and safer pest control mechanisms are recommended to enhance system reliability. Comparative studies with conventional rodent control methods are also needed to evaluate economic performance, environmental impacts, and farmer acceptance. These advancements are expected to facilitate the broader adoption of renewable-energy-based agricultural technologies and support the development of sustainable smart farming practices.

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