Pena Dimas : Jurnal Pengabdian Masyarakat V**ol.** 4 **No** 1, Page. 86-99
DOI : http://dx.doi.org/10.33474/penadimas.v4i1.27348 **e-ISSN : 2964-7789**

Solar Energy for Sustainable Tourism Management: Empowerment Model to Reduce Operational Costs on Papan Island

Andi Arham Adam[1], Yuli Asmi Rahman[2*], Fuad Zubaidi[3], Bakri Bakri[4], Muhammad Bakri[3], Fratika Julia[3], Hasbi[5], Adrin[5]

[1] Department of Civil Engineering, Faculty of Engineering, Universitas Tadulako, Sulawesi Tengah, Indonesia
[2] Department of Electrical Engineering, Faculty of Engineering, Universitas Tadulako, Sulawesi Tengah, Indonesia
[3] Department of Architecture, Faculty of Engineering, Universitas Tadulako, Sulawesi Tengah, Indonesia
[4] Department of Mechanical Engineering, Faculty of Engineering, Universitas Tadulako, Sulawesi Tengah, Indonesia
[5]Faculty of Engineering, Universitas Tadulako, Sulawesi Tengah, Indonesia
*Corresponding Author(s) Email : yuli.asmi@untad.ac.id

Article Info

Article History:
Received : 21/04/2025
Reviewed : 23/05/2025
Revised : 08/10/2025
Accepted : 23/10/2025

Keywords:
Management;
Papan Island;
Renewable Energy;
Tourism Village;

Abstract

Islands that do not have reliable access to electricity will see a decline in social and economic activity and customer satisfaction with tourism activities. Therefore, innovative tourism applications are needed so that environmentally friendly technologies installed in communities can be utilized in a positive way. The purpose of this community service activity is to promote clean energy and environmentally sustainable tourism. This project will aim to install solar energy technology for community members to illuminate public lighting that is currently unused. As a support and development activity for community members, the Participatory Action Research (PAR) model will be used together with tourism-aware community members (Pokdarwis) and the Tojo Una-Una Regency Tourism Office. Community members will design and build solar lighting systems, and then they will be trained on the integration of system control, management, and sustainable maintenance education for the design and control of solar lighting systems. Prior to the training, community-led and designed solar lights were integrated in a number of strategically developed and selected areas in Kadoda Village. Solar lights improve security and increase economic activity in the village as well as participation in village activities. This increase in activity and participation contributes to the local economy. The economic activity generated within the village demonstrates the impact of community-driven renewable energy projects, including solar energy. This community service initiative directly supports Sustainable Development Goal 7 (Affordable and Clean Energy) by expanding access to reliable and renewable energy sources in Kadoda Village.

INTRODUCTION

Since 2009, Papan Island in the Togean Archipelago has been designated as part of the UNESCO World Biosphere Reserve. This status becomes a strategic asset in promoting sustainable tourism development based on environmental conservation and biological diversity. However, the island is currently facing a significant energy challenge. Based on data from the Central Statistics Agency (BPS) of Tojo Una-Una Regency, as published in *Tojo Una-Una in Figures 2023*, the number of domestic traveler visits in 2022 experienced a significant improvement, namely by 168 percent compared to the previous year. Access to electricity is essential because it plays a crucial role in supporting the social, economic, and educational well-being of the community. Papan Island, located in the administrative area of the village of Kadoda, Tojo District, Tojo Una-Una Regency (Touna), Central Sulawesi Province (Figure 1), is one of the

tourist spots, that is currently the famous destination has become a popular spot for travelers abroad (https://jadesta.kemenparekraf.go.id/desa/pulau_papan).

Figure 1. Location of Papan Island

Papan Island is inhabited by around 40 families (KK), which is a livelihood based on fishing and traditional farming. The limited access to electricity on the island has a profound impact on the community's daily life. Data collection and interviews revealed that the electricity supply on Papan Island remains very limited, relying on three diesel generators spread across three hamlets, each with a total capacity of 15 kVA. The generators operate alternately for approximately eighteen hours each day, from 6 a.m. to 10 p.m., and the gradually decreasing working hours affect children's activities and create a sense of insecurity at night. The gasoline-powered generator and Litak countertop generator are favored for their cost and sustainability around the grab pass (Londah et al., 2023). The diesel depot is very vulnerable to commercial implosions on the island.

A generator with a load of 15 sawat hours (50%) is estimated to consume 1.5 liters of diesel, while a 10 sawat gen deck consumes 1 liter per hour. With 3 generators running for 18 hours, the total diesel fuel consumption becomes 81 liters per day per diesel generator operation and around 2,400 liters per month. These are the high operational costs that directly demote the economic and tourism competitiveness of Kadoda Village, since much of the community's income is spent on fuels. Similarly, food stalls and tourism businesses have to bear the high cost of electricity, which again raises the price of tourist services. This village has lost its competitiveness compared to other tourist destinations. This is because other locations already enjoy cheaper energy prices. Excessive use of generators also reduces the profits of village tourists. In fact, generators have the potential to cause noise and air pollution, which has an impact on the decline in tourist numbers and the image of Kadoda Village, which is known for its cool, calm, and clean natural tourism. In contrast, Talatako District can take advantage of its favorable solar energy. Moreover, Talatako District is one of the areas with the best solar energy potential, referring to the average annual solar radiation obtained, according to the local BMKG, of 5,290 kWh/m^2. Therefore, based on this and the area development plan, building a district solar power system is a green option that provides economic benefits, considering the existing potential. Additionally, it enhances the operational capacity of the location and the tourism activities offered, as the energy provided is renewable, available continuously during operational hours, and eliminates the use of fossil fuels in operations. Furthermore, the installed solar system can be independently managed by the community through a community-based energy management approach, where residents play a direct role in its maintenance and utilization. Thus, the transition from a generator-based system to solar energy is not only a technical solution for electricity supply but also a sustainable economic development strategy. The utilization of solar energy has the potential to augment the tourism competitiveness of Kadoda Village, diminish operational expenditures, elevate the comfort levels of tourists, and improve the perception of Papan Island as an energy-autonomous and ecologically sustainable tourist destination within the coastal region of Central Sulawesi.

Positioning Papan island is also strategically in the wake of efforts to maintain sustainability tourism on a variety of ecosystems (Arief & Thahir, 2020). Yet this has not been matched by readiness infrastructure and energy. Problem: The main problem of Papan Island community is limitation of energy resources and no electricity for activities during the night or day. Lack of electricity and lighting is conducive to poor quality management in tourism, such as decrease in attraction force of nighttime tourism etc. Tourists only go out during the daytime due

to the scarce lighting at night. Optional evening plans could be cultural, culinary or nautical tours by night that could also be perfectly developed. This shortens the length of stay for travelers and decreases the potential to increase income in a destination. Even tourist areas where attractions are dark can lend to the perception that it's sketchy. An average percentage of foreign travel accidents occur from car accidents, slip trips and falls on footpaths, piers or in the holiday accommodation. Security Tourism management is also based on security because nobody would go somewhere if they think that it will be dangerous or uncomfortable for them; if a country lacks proper lighting, the traveler might not come or even suggest to another tourist to experience the negative tourism in bad areas. Generators can supply electricity, but are wasteful because they need to be constantly refueled. For individuals whose livelihoods are contingent upon the tourism sector, operational expenditures escalate significantly, thereby diminishing profit margins From a manager's perspective, this is a potential for unsustainable dependence, as well as a very vital, unstable, and risky problem. The use of fossil fuel generators contributes to pollution that is not only contaminating but also causes noise pollution and carbon emissions that are harmful to the environment. These conditions can affect the reputation of Papan Island, which is open to ecotourism. This means that it does not use an "environmentally friendly" approach, which in reality is marketed as "environmentally friendly" and is a major attraction for foreign tourists (Bangse et al., 2024).

Electrical problems not only cause technical issues, but also tourism management issues, uncompetitive energy, unsustainable economics, and the image of tourism itself. Papan Island is being developed with arrangements and plans that have been set up for a solar lighting system and has been established as a vision for more modern and effective tourism development for the concentration and management of Papan's tourism objectives (Islam, 2025); Nugraha & Desnanjaya, 2025)). This lighting can, on the one hand, enrich and enhance the tourist experience, but on the other hand, it can also maintain the island's security 24 hours a day, increase profits, and create tourist attractions with a narrative of Papan that includes sustainability.

Limited knowledge and skills of the public in utilizing renewable energy technologies, such as solar, can become a solution for a more energy-efficient and environmentally friendly environment (Rahman et al., 2023). Based on data from the BMKG Poso station, the average potential solar energy in the sub-district of Talatako in 2023 is approximately 5,290 kWh/m². Identification results existing problems, formulation problem in activity devotion This is How method give access to a sustainable and environmentally friendly lighting environment for the people of Papan Island as village tourism (https://kanaldesa.com/artikel/pulau-papan-pesona-wisata-desa-kadoda) via technology light power solar as well as How to build public awareness about importance energy renewable as well as the ability for maintain and manage system power solar in a way independent.

As a solution to the problem, this technology, light power solar (solar cell), is an alternative energy source that is appropriate, efficient, and sustainable. The application of system lighting based on solar Power can meet the need for lighting without relying on conventional network-dependent electricity (Pradana, 2023). Additionally, technology is also convenient in terms of care and very suitable for remote areas with intense sunlight, such as in the Papuan Island area. In general, detailed activities are devoted to this aim, for introducing and installing solar-powered lighting on Papan Island to increase access to efficient, sustainable, and environmentally friendly lighting. This activity also provides the public with training on the method, use, care, and maintenance of solar-powered lights, empowering them to manage the system independently. This initiative aims to increase awareness of the importance of utilizing renewable energy in daily life, supporting sustainability in social and economic development sectors, and promoting village development through tourism. This is the result of a strong collaboration between the team implementer and the public, in partnership with the Tourism Office of Tojo Una-Una Regency. The collaboration is essential since it focuses on implementing village-independent energy by empowerment programs, public-based technology, and appropriate technology. It gives a guarantee that the community does not only receive the solution but is also involved in the implementation process.

http://dx.doi.org/10.33474/penadimas.v4i1.27348

Besides the installation of a light unit powered by solar energy, activities also involve education for the inhabitants related to the usage, maintenance, and management systems in an independent way so that, in the future, the program can be sustainable. With an appropriate and friendly lighting environment, Papan Island has great potential for development to be an interesting tourist destination due to the ability to move the local economic growth and to give different experiences for visitors on the island (Istiqomah et al., 2020). This program introduces solar-based lighting as an energy innovation and also as a management model to reduce operational expenses related to electricity, which will increase the sustainable tourism management and local economic independence.

IMPLEMENTATION METHOD

Community service activities in the public sector, focusing on the people of Kadoda Village, especially residents of Papan Island, who are members of the Tourism Awareness Group (Pokdarwis). With the active participation of Pokdarwis, which has 15 enthusiastic members and is led by Darwis, this makes them an integral part of the program.

The community service program will also be very community-oriented. All residents of Papan Island will be the direct beneficiaries, amounting to 38 heads of families (KK) with a population of around 150 people. Members are from the Faculty of Engineering, Tadulako University: four multidisciplinary lecturers and power field-trained personnel to assist in on-site implementation. Support was added from the Tourism Office of Tojo Una-Una Regency, which played a role as a facilitator of policy and time connector with a development agenda for the village tour regency.

Implementation Activities: Papan Island, Kadoda Village, Tojo District, Tojo Una-Una Regency, Central Sulawesi. This island is part of the Togean Archipelago and was designated as a UNESCO World Biosphere Reserve in 2009. Within 6 months, from August 2024 to January 2025, a series of activities will be carried out, including preparations, implementation, education, and evaluation of what happened after the program. Installing solar power at several strategic points on the island, namely houses, main roads, villages, public areas, and for a tour.

The approach taken in this activity is Participatory Action Research (PAR), which prioritizes the active participation of the public, starting from the planning stage to evaluation (Soedarwo et al., 2022). Through this method, society not only becomes a recipient of benefits but also participates and plays a role as program designers, implementers, and managers (Sulaiman et al., 2022). Implement stages of activity according to Figure 2.

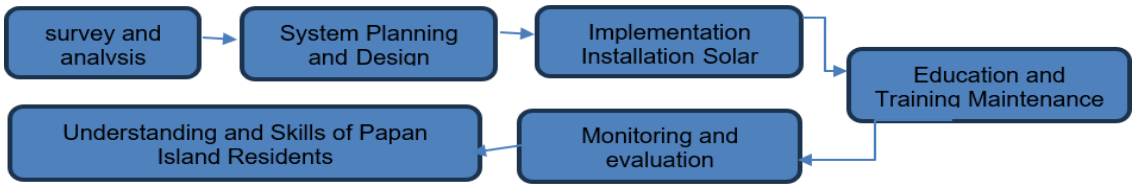


Figure 2. Step of community service

The impact on tourism is evident in improved security at night, increased comfort for tourists, as well as participation in the tourism group for the promotion and management of village tour-based renewable energy (Pandyaswargo et al., 2024). These positive impacts are a testament to the success of the program and should inspire optimism and support among the stakeholders. Approach to activity devotion. This employs the Participatory Action Research (PAR) method. This method pushes participation directly from the public, allowing inhabitants to follow the design, implementation, and evaluation of installation programs for light energy. Involving the active public makes them feel a sense of ownership in the results of activities, such as public involvement in the installation of identification points for solar power. This is essential for ensuring the sustainability of solar panel and battery using and maintenance through education and training processes. Directly involved in activities, society not only accepts help with technology but also acquires knowledge and skills about the technical aspects of solar energy.

Because the community is involved from the beginning to the end, potential long-term program sustainability is significantly greater compared to a top-down approach.

Figure 2. Installation design solar power lamp

In these activities, the team's focus is on working with the public to identify real problems faced in the village of Papan Island, particularly those related to lighting limitations and their impact on social and economic life (Adi et al., (2023); Novitasari et al., (2020); del Arco et al., (2021)). At this stage, the team conducts a survey early on Papan Island to identify the geographical conditions, lighting needs, and available infrastructure. This survey also aims to explore the potential and challenges faced by the public in accessing electricity, as well as identify the key strategic points for the installation of solar power. At the second stage, based on the results of the survey, a team consisting of a lecturer, an architect, and a lecturer in civil techniques will design the layout and design of the installation of solar power at various strategic points (Figure 2), such as houses, main roads, and public areas.

This design will be customized according to the geographical and social conditions of the community. Engineering lecturer responsible for designing a power-efficient solar system, ensuring sufficient power for lighting at night. Lecturer techniques play a role in selecting and procuring equipment that is appropriate for the field conditions. A participatory society at this stage involves them in the discussion and planning to ensure that the design is made in accordance with the conditions and needs of the local community. At this stage, third, after stage planning is finished, the installation of the system light, power, and solar in the locations that have been agreed upon, at this stage, two forces the field that has been trained and the local public, who are also involved in the installation process, work together to increase the sense of ownership and understanding of the technology used (Saparullah et al., 2023). Installation process. This covers solar panel installation (Figure 3), which will be guided by the members' team from each field of expertise. Participation in a society is critical at this stage. They participate in the installation of equipment, understand technical processes, and learn how to use a nurse system. Involvement ensures that the community feels a sense of ownership over its installed system and can be responsible for its maintenance. The team and the local public completed the installation, and an educational session was held for the community on the use and maintenance of solar-powered lights. This purposes for ensuring that society can control the system in a way that is independent and sustainable. Training will cover the basics of solar panel maintenance (Sunarjanto et al., 2024), including replacement of batteries, as well as methods for maintaining the guard system to ensure optimal performance.

During the evaluation and monitoring stage, the Community Service Team, in collaboration with the community, assesses the effectiveness and sustainability of the solar power system after several months of installation. The team not only gathers feedback from the community and Pokdarwis about the impact of this activity on their social and economic lives but also empowers them to be part of the evaluation process. For measuring the level of success in activity devotion, the indicators used are changes in attitudes and social culture. As for the way to measure level achievement, success includes change in attitude, assessment done through pre- and post-installation surveys that measure understanding and acceptance of the public to use renewable and solar light power and change social culture through observation, direct interviews, and measuring changes in public participation in social activities, such as cooperation in the nursing system or the sustainability management of tourist villages based on renewable energy.

Respondents consist of members from the Papan Island community, specifically 38 heads of families who became the main subjects for evaluating changes in attitudes and social behavior.

http://dx.doi.org/10.33474/penadimas.v4i1.27348

In addition, Pokdarwis also becomes an object of measurement for assessing the impact of the management village tour.

RESULTS

1. Characteristic of participants

This program involves 38 heads of Family (KK) as the direct recipients and 15 members of the Tourism Group as the main partners. Of all participants, 65% are men and 35% are women. Men work in traditional roles, whereas women play a role in processing results, sea activities, housework, and the management of homestays. Participants aged between 20 and 60 years, with a group age of 30–45 years dominating at 55%, followed by those aged 20–29 years (20%) and 46–60 years (25%). The majority of participants work as fishermen (70%), followed by small business owners and artisans (15%), homestay managers (10%), and individuals in other informal jobs (5%). Most of them are public elementary–middle school education (60%), high school (30%), and college (10%).

Table 1. Characteristics Public

Indicator	Distribution	People
Gender	Man	25
	Women	13
Age group	20–29 years	8
	30–45 years	22
	46–60 up years	8
Education	Primary-Junior High School	23
	Senior High School	15
Occupation	Fisherman	26
	Craftsman	6
	Homestay manager	4
	Others	2

Characteristics Table 1 shows that the people of Papan Island have power. Work highly productive, but the level of relative education is low demanding a simple, visual, and participatory knowledge transfer method in the implementation of the community service program stages.

2. Implementation of the stages of community service activities

Step 1: Initial survey and analysis need

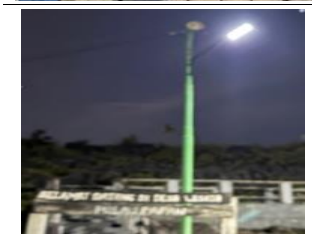
The activity started with a visit by the team and a a discussion with chairman Pokdarwis and the services of Tourist Tojo Una-Una district. An activity was held at the Marina Beach pier to identifying the actual condition and the needs of the of the real community on Papan Island. Discussion results show that the public is relies on community generators for lighting needs, with operational costs borne by residents per house and time limited generator operation from 18:00 to 22:00 WITA. This matter affects the nighttime activities of children and requires lighting in public areas, such as the pier and the main village road.

Step 2: Planning and design System

Based on the survey results, the team designed a system utilizing light-powered solar, with 20 Wp in one solar panel, to meet basic lighting needs. Strategic installation determined through discussion with the figure community and head hamlet, includes two units for house citizens used as a center activity social evening, one unit at the dock main, one unit on the road connector between house, and one unit in an open area that is often used as a place to gather. The team provided five light units, solar, and five handle units, iron, as support. Handle

iron made independently in the mechanical engineering laboratory, Faculty of Engineering, Tadulako University.

Table 2. Description of Activities

Documentation Photo	Describtion
	Socialization of the program to be implemented to partners
	Solar panel design used to support lighting
	Installation of panels and lights
	The solar panels are functioning properly.
	Training related to operational management

Step 3: Implementation: Installation of Solar Powered Lamps

Installation was completed over two days, with the assistance of the inhabitant as a technical expert to foster engagement and increase understanding (Kusuma et al., 2023). This process also functions as part of direct training (learning by doing). Departure to the location using a sailboat service for tourists. During the installation process, residents were divided into two groups to help connect cables and install panels at each point. Session training given to inhabitants related to solar panel work and system storage energy, ways to clean the panel and check the connection, and simple maintenance procedures, such as checking the battery and LED lights.

http://dx.doi.org/10.33474/penadimas.v4i1.27348

Step 4. Education and Training Maintenance

After the installation was completed in accordance with the plan (Figure 8), a training session was held to educate the public on the methods of using, maintaining, and repairing solar light power systems (Rumbayan et al., 2021). Training aims to ensure that society can manage the system independently and sustainably. In addition, the community is also given knowledge about renewable energy and its benefits in everyday life, which is beneficial for the housing ladder and for activity tourism (Figure 8). The teamalso distributed a simple manual outlining the steps for periodic maintenance. The results of the agreement indicate that two individuals appointed as guarantors will periodically answer technical questions for supervision.

3. Evaluation and Monitoring

To measure changes in society before and after activities, the team conducts questionnaires as a form of monitoring before the activity is accomplished. The results obtained are shown in Table 3. Based on the pre-test results presented in Table 3, the level of community understanding and attitude toward renewable energy in Kadoda Village, Papan Island, reflects the early stage of adaptation to sustainable energy technology. The data show that only 24% of respondents had a positive attitude toward renewable energy, while 37% remained neutral and 39% still expressed negative perceptions. This shows that before the solar lamp intervention, a large part of the beneficiaries were yet to appreciate the economic and environmental attributes of the renewable energy source. According to the Expectancy-Disconfirmation theory (Oliver, 1980), satisfaction is experienced when the program outcomes are ahead of expectations, especially on the aspects of comfort and efficiency on energy use. Technical capacity: On technical capacity, only 8% reported having good knowledge of how to maintain the solar system, while 26% had a fair level of understanding and 66% were ignorant about the solar systems. This aspect is among the most compelling challenges in sustainably maintaining renewable energy systems due to their vulnerability to inefficiency and long-term malfunctions due to limited technical knowledge. Economic Business: Using these pointers, the community in its pre-intervention stage has not yet considered renewable energy as an alternative for local economic growth, either for entrepreneurship in tourism businesses. Low levels of awareness impede the community's preparedness to engage in business activities such as homestay operation, local product processing, and tourism services using clean energy. Similarly, the economic attainment indicators at the initial level, therefore, were at minimum levels of cost savings, productivity increase, or value addition business potentials before the project implementation.

These pre-test results are indeed an important benchmark against which the impacts of community service interventions will be measured. The solar-powered lighting installations, accompanied by some training activities afterwards, are expected to improve both attitude-which relates to the awareness-and capability, which pertains to the technical understanding of the community-measurable improvements in economic performance indicators of reduced energy expenses, increased business activities in the evening, and increased competitiveness of the Kadoda Village as a sustainable tourism destination.

Table 3. Monitoring level understanding of the inhabitant

Indicator	Distribution	Respondents (people)	Percentage (%)
Attitude towards Renewable Energy	Positive	9	24
	Neutral	14	37
	Negative	15	39
Understanding about Maintenance	Good	3	8
	Enough	10	26
	Not enough	27	66

The average overall participation is not less than 76% of the total head families, which is 38. This also emanates from the fact that in PAR, the principle of involvement of residents in the implementation process instills a sense of ownership and responsibility among them for program sustainability (Kusuma et al., (2023); Rumbayan et al., (2021).

Table 4. Respondent results *Post-test*

Indicator	Distribution	Respondents (people)	Percentage (%)
Attitude towards Renewable Energy	Positive	22	58
	Neutral	11	29
	Negative	5	13
Participation in Activity Social	Tall	19	50
	Currently	12	32
	Low	7	18
Understanding about Maintenance	Good	20	52
	Enough	10	38
	Not enough	8	20
Understanding about operasional cost and energy	Good	22	58
	Enough	10	26
	Not enough	6	16

The high rate of participation supports the CBT theory (CBT) theory, which signifies that booming destination tourism relies on the role of active public local in planning and management (Tosun, (2006); Muliatie et al., (2023)). This community service activity applied four indicators for measuring the success of the program:

1. Attitude toward Renewable Energy: This indicator indicates acceptance, perceived benefit, and readiness to use solar energy for the community living on Papan Island, which should exceed 55%.
2. Understanding of Maintenance: This indicator refers to technical knowledge of the community in maintaining and operating solar energy on Papan Island, which exceeds 50% to guarantee the sustainability of the project.
3. Community Participation and Involvement: The "active engagement of the community is a cornerstone of the sustainability of our program" on Papan Island, which is measured by participation concerning the level of interest from the community over the planning, implementation, and evaluation of the activities proposed, with a successful achievement above 50%.
4. This "Understanding of Operational and Energy Costs" indicates the degree of awareness of communities regarding the understanding of how much energy systems-solar-powered streetlights-are impacting their household and communal expenses. The success in the understanding is determined by achieving 50% participation and above.

Monitoring and evaluation activities were also carried out by the team after the event to measure the achievement of the target indicators, and the results are presented in Table 4.

DISCUSSION

Solar-powered lamps in Kadoda Village, Tojo Una-Una, Central Sulawesi, illustrate the success of technological intervention while also illustrating the first steps in the social learning process of the island's social and cultural community. Like other remote areas in Central Sulawesi, Kadoda has historically relied on poorly maintained diesel generators that provide minimal

http://dx.doi.org/10.33474/penadimas.v4i1.27348

service, which in turn limits what can be done economically at night (Rumbayan et al., 2021); (Samudra & Hidayah, 2023)).

The adoption of solar technology in Kadoda stemmed from culturally aligned community cooperation, the perceived local advantages of solar technology over diesel systems, and the economic and social benefits of extended working and study hours at night. The active involvement of community members in the installation of the system provides an important social context for understanding the installation of collaborative solar systems. This frames solar technology not merely as an imported innovation, but as something that is worked on together by the community. This social perspective, in a psycho-social sense, allows the community to relinquish ownership for emotional retention and gives them a sense of commitment.

The social aspects of this learning method are consistent with Bandura's Social Learning Theory, which describes how self-efficacy and belief in a system are developed through direct experience and observation. Systematic infrastructure maintenance accompanies the tradition of renewable energy as a new intervention that transforms community identity and local pride. Social learning has been documented in the context of the islands of Nias and Sumba to strengthen sustainability (Uddin et al., 2025).

Applying Zimmerman's Empowerment Theory (Zimmerman, 2000) and Freire's concept of conscientization, it can be said that participation in Kadoda goes beyond mere collaboration. It represents the reclaiming of agency in local energy governance. For places like Kadoda, where dependence on electricity has been externally determined throughout time, the literacy required for the autonomy of installation and maintenance of solar power systems strengthens the desire to provide and operate while avoiding patterns of dependence.

As ‘local maintenance’ of Pokdarwis, community groups in Kadoda are contractually bound to the development of governance modules that enable the formation of social capital as defined in (Putra et al., 2023). Social capital, along with trust, also includes shared expectations, collective norms, and highly interconnected and cooperative networks of various compositions. This understanding is in line with findings from a highly customized community solar power system in rural Sulawesi, where the performance of the commission is closely related to the disclosure of the system's functionality over time.

Under Oliver's Expectancy-Disconfirmation Theory, with the provision of sleep and all activities required by Kadoda residents after dark, what exceeds their expectations is comfort and productivity, which likely gives them the dignity to assert their membership in a modern independent village. Mezirow's Transformative Learning Theory in his writing describes a case of reflective adaptation from the example above. The residents of Kadoda village, unlike the previous example, who saw electricity as an external commodity, now see energy as a shared asset. Such a change is in line with cognitive transformation in defining social relationships in terms of moral relationships of social closeness. This illustrates a process of transformational learning with the social dimension of renewable energy adoption as the focal point.

The Kadoda case illustrates the interrelated social, economic, and environmental linkages in the context of the Sustainable Development Goals, particularly SDG 7 and the principles of the Integrated Framework for Sustainable Development Goals (SDGs). For Kadoda, renewable energy serves as an ecological asset and offers opportunities to diversify livelihood commodities. Reliable solar energy extends daylight hours after dark, enabling the community to engage in small-scale trade, trade-related meetings, and community gatherings, as well as local fishing, thereby deepening economic dependence. This shifts the social environment of the community for the better and improves the position of women. Such circumstances exemplify energy justice and equity, while the situation in Tojo Una-Una is in line with the scenario described by Asad et al., (2022) in which the logistical challenges of reducing fuel costs and implementing solar power systems reduce operational costs and emissions, thereby improving the region's energy security.

The Kadoda community service program has shown that collaboration between technological innovation and social empowerment has a positive impact both materially and cognitively. The term material transformation refers to improvements in infrastructure and energy costs in the community. Meanwhile, the term cognitive transformation refers to the strengthening of communities, local government structures, and self-adopted practices. Understanding technology as a social construct is very important. A deeper understanding must highlight

culturally participatory and adaptive systems (Prahastono et al., 2022). This can be seen in Kadoda, where the local community works together to produce technological transformation.

The focus of long-term sustainability in Kadoda is on the institutional learning cycle, which is currently stalled. This includes, but is not limited to, training on routine maintenance, integrating energy literacy into school curricula, and group collaboration between communities, local governments, and academic institutions. Incorporating education on solar renewable energy into the Tojo Una-Una tourism program will promote (Ministry of Tourism and Creative Economy, 2021) socio-economic and cultural sustainability, especially in the growing ecotourism sector. The sustainability of this model for implementation on other islands in Central Sulawesi requires careful attention to participatory governance and local adaptation. This is to ensure that solar initiatives within a socio-ecological framework are designed to be robust and durable.

CONCLUSIONS

During Ramadan, community services on Papan Island implemented solar power generators in five strategic locations in Kadoda Village. Lectures at higher education institutions on Papan Island integrated solar power generators with educational solar tools, which inspired the community's dreams. Based on a survey, 58% of respondents expressed a positive response to the attitude and use of renewable energy, proving that solar lights have been accepted and used by the community. In addition, 50% of respondents showed positive social participation and connection to the issues raised directly. The installation of solar lights improved community relations and strengthened the community. 52% of respondents actively discussed and directed their understanding of the principles of solar system maintenance, both within and outside the community. The above-mentioned solar system maintenance education was very meaningful for the community. The existence of solar power plants during Ramadan and the following months increased knowledge and helped organize the community systematically. Public enthusiasm indicates strengthened social cohesion and independent energy management in the community. However, island access, implementation timeframes, variations in residents' skill levels, and maintenance resources, technical and solar system equipment remain challenges. The management of solar systems, accumulators, and panels is lacking due to a fundamental lack of knowledge about system maintenance. The expansion of the system, maintenance, and resources provided for the system are also inadequate because not all households are connected. One indicator shows positive results. Before the community service activities, residents on Papan Island depended on diesel generators, which were only available in three hamlets and were very expensive to operate. The economics of the system were fuel costs and limited operating hours. These resources reduced household income for basic necessities and reduced local tourism activities. Dependence on fossil fuel generators was a source of unexpected expenses. After the installation of solar-powered street lighting, communities started to understand the economic benefits of renewable energy. In this case, the residents learned through participatory training and hands-on experiences that there is a drastic reduction in the operating cost of solar power systems, with sunlight being freely available and requiring little maintenance compared to oil-fueled generators. They also realized that although the initial installation cost is comparatively higher, it is offset by the long-term fuel and maintenance savings, which guarantees cost efficiency and energy security for public facilities.

A number of follow-up steps that are recommended for the future development include periodic maintenance and troubleshooting training for the solar power systems, scaling up the system to cover more households and public facilities, strengthening collaboration with local government and the private sector to expand access and funding for renewable energy development on Papan Island, and exploring the local economic potentials supported by sustainable electricity, such as eco-friendly homestays and energy-based local crafts. It is with continuous support and a participatory model that Papan Island has strong potential to become a model of a clean-energy-based community-driven eco-tourism village in the coastal region of Central Sulawesi. Integrating solar energy within eco-tourism branding, or "Green Island Tourism"; promoting small-scale entrepreneurship related to solar energy, such as solar-powered homestays or night tourism services; partnerships with local governments and private sectors for system scaling and training support; strengthening the monitoring mechanisms for long-term

http://dx.doi.org/10.33474/penadimas.v4i1.27348

maintenance and business viability. These additions connect technical outcomes to broader tourism management and economic sustainability goals.

ACKNOWLEDGEMENTS
The author would like to thank the Faculty of Engineering, University of Tadulako, LPPM Untad, the Tourism Office of the Regency of Touna, the government village of Kadoda, as well as the Tourism Group of Papan Island.

CONFLICT OF INTEREST
All authors declare no conflicts of interest that could influence the results, interpretations, or compilation of this article. All activity devotion is publicly implemented in a manner independent of personal, commercial, financial, or institutional interests that could create bias against the implementation and reporting of the activity's results.

FUNDING
Activity devotion funded from the DIPA for Community Service, the collaborative Faculty of Engineering, Tadulako University

REFERENCES
Adi, A. F., Ndari, P. W., Meyana, Y. E., & Arkho, A. (2023). Pemberdayaan Masyarakat dalam Pengelolaan Desa Wisata Pantai Tanjung Penyu Kabupaten Malang. *Jurnal Pengabdian Masyarakat*, *1*(4), 1–4. https://doi.org/10.62818/jpm.v1i4.19

Arief, I., & Thahir, H. (2020). Community Based Tourism for the Concept of Village Tourism Facility Development in Papan Island. *IOP Conference Series: Materials Science and Engineering*, *797*(1), 012006. https://doi.org/10.1088/1757-899X/797/1/012006

Asad, M., Mahmood, F. I., Baffo, I., Mauro, A., & Petrillo, A. (2022). The Cost Benefit Analysis of Commercial 100 MW Solar PV: The Plant Quaid-e-Azam Solar Power Pvt Ltd. *Sustainability*, *14*(5). https://doi.org/10.3390/su14052895

Bangse, K., Midiani, L. P. I., Arsana, M. E., & Widiantara, I. B. G. (2024). Penyediaan Infrastruktur Lampu Jalan Berbasis Solar Panel untuk Mendukung Pengembangan Desa Ekowisata Berkelanjutan Desa Munduk Kecamatan Banjar Kabupaten Buleleng. *Jurnal Pengabdian Masyarakat Bangsa*, *2*(10), 4283-4288. https://doi.org/10.59837/jpmba.v2i10.1690

del Arco, I., Ramos-Pla, A., Zsembinszki, G., de Gracia, A., & Cabeza, L. F. (2021). Implementing SDGs to a Sustainable Rural Village Development from Community Empowerment: Linking Energy, Education, Innovation, and Research. *Sustainability*, *13*(23). https://doi.org/10.3390/su132312946

https://jadesta.kemenparekraf.go.id/desa/pulau_papan, accessed online on July 20, 2025.

https://kanaldesa.com/artikel/pulau-papan-pesona-wisata-desa-kadoda, accessed online on July 20, 2025.

Islam, M. A. (2025). The effects of tourism, energy consumption, and technological innovation on environmental quality amid geopolitical risk in Canada. *Discover Energy*, *5*(1), 11. https://doi.org/10.1007/s43937-025-00071-x

Istiqomah, Adawiyah, W. R., Praptapa, A., Kusuma, P. D. I., & Sholikhah, Z. (2020). Promoting local potential as a strategy to develop tourism village. Geo Journal of Tourism and Geosites. *Geo Journal of Tourism and Geosites*, *31*(3), 1113-1118. https://doi.org/10.30892/gtg.31324-547

Kusuma, H. A., Suhendra, T., & Yunianto, A. H. (2023). Pelatihan Teknologi Penerangan Jalan Umum Berbasis Tenaga Surya Di Desa Benan, Kabupaten Lingga, Kepulauan Riau. *Jurnal Hilirisasi IPTEKS*, *6*(3), 322–334. https://doi.org/10.25077/jhi.v6i3.700

Londah, R., Dotulong, D., & Kawuwung, Y. (2023). Analisis Penggunaan Pembangkit Listrik Menggunakan Energi Baru dan Terbarukan pada Obyek Wisata Bahari di Pesisir Kota Manado. *Jurnal Multidisiplin Ukita*, *1*(3), 175–184.

Ministry of Tourism and Creative Economy. (2021). *Sustainable Tourism Guidelines for Island Destinations*.

Muliatie, Y. E., Sri Suprapti, Gita Fitri Sakinah Putri, Putri Nurlaili Susanti, Linda Asih Pratiwi, & Gani Sutrisno. (2023). Revitalisasi Tempat Wisata Watoe Delean Prigen Sebagai Pariwisata Unggulan Desa Sukoreno. *PENA DIMAS: Jurnal Pengabdian Masyarakat*, *2*(1), 44–51. http://dx.doi.org/10.33474/penadimas.v2i1.22700

Novitasari, D., Salis, F. R., Budiarto, R., & Sarjiya. (2020). Challenges In Using Renewable Energy for Islands in Indonesia: A Case Study of Karimunjawa. *2020 International Conference and Utility Exhibition on Energy, Environment and Climate Change (ICUE)*, 1–8. https://doi.org/10.1109/ICUE49301.2020.9307078

Nugraha, I. M. A., & Desnanjaya, I. G. M. N. (2025). Optimization of renewable energy based electrical systems on tourist ships in Labuan Bajo. *International Journal of Power Electronics and Drive System*, *16*(2), 1306–1313. https://doi.org/10.11591/ijpeds.v16.i2.pp1306-1313

Oliver, R. L. (1980). A Cognitive Model of the Antecedents and Consequences of Satisfaction Decisions. *Journal of Marketing Research*, *17*(4), 460–469. https://doi.org/10.1177/002224378001700405

Pandyaswargo, A. H., Wibowo, A. D., Sunarti, S., Risnawati, & Onoda, H. (2024). A needs-based approach to sustainable energy use: Case studies of four remote villages in Indonesia. *Environment, Development and Sustainability*. https://doi.org/10.1007/s10668-024-05572-8

Pradana, B. A. (2023). Prototype Penerangan Jalan Umum Tenaga Surya (PJU-TS) Sistem Dinamis. *JUPITER (JURNAL PENDIDIKAN TEKNIK ELEKTRO)*, *8*(2), 1. https://doi.org/10.25273/jupiter.v8i2.17740

Prahastono, I., Paradongan, H. T., Aditya, I. A., Banjarnahor, K. M., & Sinisuka, N. I. (2022). Photovoltaic Power Plant Feasibility Study Based on Indonesia's Renewable Energy Tariffs: A Study of Nusa Penida Solar Power Plant. *International Journal of Energy Economics and Policy*, *12*(6), 500-512. https://doi.org/10.32479/ijeep.14659

Putra, R. D., Nugraha, S., & Setiadi, R. (2023). Social Capital and Empowerment in Island-Based Renewable Energy Projects in Indonesia. *Asian Development and Policy Review*, *11*(1), 45-59.

Rahman, Y., Anwar, K., Mardjudo, A., & Din, M. (2023). *Electric Lighting on the Fishery Boat Lift Net of Tomini Bay Using a Portable PV-Generator System* (p. 630). In Proceedings of the 8th International Conference on Sustainable Information Engineering and Technology. https://doi.org/10.1145/3626641.3626947

Rumbayan, M., Agustinus, S., & Tangkuman, S. (2021). Potential and Implementation of Renewable Energy Systems in Eastern Indonesia: Lessons from Sulawesi. *IOP Conference Series: Earth and Environmental Science*, *819*, 012043. https://doi.org/10.1088/1755-1315/819/1/012043

Rumbayan, M., Sompie, S., & Rumbayan, R. (2021). Penerapan Teknologi Energi Terbarukan Melalui Model Science Techno Park Di Desa Kiama Kepulauan Talaud. *Jurnal Abdimas Indonesia*, *1*(4), 1–9. https://doi.org/10.53769/jai.v1i4.137

Samudra, D., & Hidayah, I. (2023). Economic Feasibility Analysis and Financing Model of Solar Power Plant Projects in Indonesia. *Alphabisz Journal of Management and Digital Business*, *1*(1), 1-10.

Saparullah, Mufti, N., Ali, H., Wibowo, S. R., Puspita, A. S., Dewi, Saidah, F. N., Paradita, D., Nasikhudin, & Muntholib. (2023). Pengembangan Eduwisata Sebagai Bentuk Dukungan Income Generating Daerah Wisata Dilem Wilis. *PENA DIMAS: Jurnal Pengabdian Masyarakat*, *1*(2), 66–71. http://dx.doi.org/10.33474/penadimas.v1i2.18902

Soedarwo, V. S. D., Fuadiputra, I. R., Bustami, M. R., & Jha, G. K. (2022). Participatory Action Research (PAR) Model for Developing A Tourism Village in Indonesia. *Journal of Local Government Issues*, *5*(2), 193–206. https://doi.org/10.22219/logos.v5i2.21279

Sulaiman, A. I., Chusmeru, Adi, T. N., & Runtiko, A. G. (2022). Community empowerment as socio-economic education of tourism villages based on local wisdom. *Education Quarterly Reviews*, *5*(3), 54–67. https://doi.org/10.31014/aior.1993.05.03.524

Sunarjanto, D., Widarsono, B., Sugihardjo, Suliantara, Atmoko, A. D., Romli, M., Setiawan, H. L., Susantoro, T. M., Suhartono, R., Dwiyanarti, D., & Nurkamelia. (2024). Optimizing the

development of renewable energy and fossil energy during the energy transition in Indonesia: A paper review. *AIP Conference Proceedings*, *3069*(1), 020093. https://doi.org/10.1063/5.0206075

Tosun, C. (2006). Expected nature of community participation in tourism development. *Tourism Management*, *27*(3), 493–504. https://doi.org/10.1016/j.tourman.2004.12.004

Uddin, M., Mo, H., & Dong, D. (2025). Integrated energy management for operational cost optimization in community microgrids. *Energy Reports*, *11*, 1423-1438. https://doi.org/10.48550/arXiv.2503.08009

Zimmerman, M. A. (2000). Empowerment Theory. In J. Rappaport & E. Seidman (Eds.), *Handbook of Community Psychology* (pp. 43–63). Springer US. https://doi.org/10.1007/978-1-4615-4193-6_2