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# Education on Energy Efficient Underwater Light Emitting Diode (LED) Technology for Boat Lift Nets in Aceh Besar

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## Abstract

The coastal areas of Aceh Besar have high fisheries potential, but traditional fishermen using bagan boats in Gampong Lhok Layeun are facing declining catches due to technological limitations. The conventional lights used have limited light coverage and high fuel consumption. This service activity aims to improve the knowledge and skills of fishermen through education on energy-efficient underwater Light Emitting Diode (LED) technology as an alternative solution. The implementation method includes four stages: initial survey, socialisation, discussion, and evaluation and monitoring. The activity involved 25 participants consisting of fishermen, Panglima Laot, academics, and village officials. The results showed an increase in participants' understanding of underwater LED technology, with an average pre-test score of 57 increasing to 84 in the post-test. A total of 100% of participants expressed interest in adopting this technology, and showed high enthusiasm during the socialisation and discussion. This activity proves that participatory and educative approaches can strengthen traditional fisheries innovation at the local level.
***Keywords:*** *, boat lliftnet, Community service, energy efficiency, fisheries technology, underwater LED*

## Abstrak

Wilayah pesisir Aceh Besar memiliki potensi perikanan yang tinggi, namun nelayan tradisional pengguna bagan perahu di Gampong Lhok Layeun menghadapi penurunan hasil tangkapan akibat keterbatasan teknologi. Lampu konvensional yang digunakan memiliki jangkauan cahaya terbatas dan konsumsi bahan bakar tinggi. Kegiatan pengabdian ini bertujuan untuk meningkatkan pengetahuan dan keterampilan nelayan melalui edukasi teknologi *underwater Light Emitting Diode* (LED) hemat energi sebagai solusi alternatif. Metode pelaksanaan mencakup empat tahap: survei awal, sosialisasi, diskusi, serta evaluasi dan monitoring. Kegiatan melibatkan 25 peserta yang terdiri atas nelayan, Panglima Laot, akademisi, dan perangkat desa. Hasil kegiatan menunjukkan adanya peningkatan pemahaman peserta terhadap teknologi *underwater* LED, dengan nilai pre-test rata-rata sebesar 57 meningkat menjadi 84 pada post-test. Sebanyak 100% peserta menyatakan minat untuk mengadopsi teknologi ini, dan menunjukkan antusiasme tinggi selama sosialisasi dan diskusi. Kegiatan ini membuktikan bahwa pendekatan partisipatif dan edukatif mampu memperkuat inovasi perikanan tradisional di tingkat lokal.

**Kata Kunci:** bagan perahu, efisiensi energi, LED bawah air, Pengabdian masyarakat, teknologi perikanan

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## INTRODUCTION

The coastal region of Indonesia is one of the areas with the greatest marine biodiversity in the world (Rahmah et al., 2025). According to the Food and Agriculture Organization (FAO), Indonesia ranks among the top three countries contributing the most to global capture fisheries production (92,3 million tons or 8,0% in 2022). One of the provinces rich in fisheries resources is Aceh, particularly Aceh Besar District, located on the west coast of Sumatra (Nuraga et al., 2018). This area directly borders the Indian Ocean, which is known for its high fisheries productivity, including small pelagic fish, large pelagic fish, and demersal fish (Himam et al., 2018). These fishery resources serve as the main livelihood for coastal communities, the majority of whom work as traditional fishers (Olii et al., 2021).

In the socio economic context, the presence of traditional fishers in Aceh Besar is closely tied to the use of lift nets (Kurnia et al., 2024). This fishing gear remains widely used because of its simple construction, relatively lower production cost compared to modern fishing vessels, and its suitability for operation by small fisher groups. The working principle of the lift net relies on the use of light as an attractor to gather fish beneath the boat before the net is lowered. Therefore, the effectiveness of the lighting system becomes a key factor in the success of fishing operations (Susanto et al., 2020).

In recent years, boat lift-net fishers in Gampong Lhok Layeun, Leupung Sub district, have experienced a significant decline in their catch (Fajri et al., 2019). Local fishers reported that even though they have increased the number of lamps and fuel used, their catches have remained stagnant or even decreased. This phenomenon is influenced by several factors. First, climate change has affected fish migration patterns (Islam et al., 2022). Second, coastal habitat degradation has occurred, including coral reef damage and the reduction of mangrove cover, which serves as an important nursery ground for fish (Rahman et al., 2021). Third, there are limitations in the fishing technology used by traditional fishers, particularly the reliance on conventional lighting systems (Rahman et al., 2021).

Conventional lamps used on boat lift nets are generally installed above the water surface. The primary limitation is that light emitted from these lamps cannot effectively penetrate the water column. This is due to the surface layer of the water reflecting a large portion of the light back into the air, leaving only a limited intensity of light entering the water. In addition to technical limitations, another major problem faced by fishers is the high operational cost. Conventional lamps typically rely on fuel-powered generators as their energy source. In a single night of operation, fishers may consume approximately 5–10 liters of fuel per night solely for lighting purposes.

Under these circumstances, there is an urgent need for alternative technology that is more efficient, environmentally friendly, and affordable for traditional fishers. One of the innovations that has increasingly been developed is the use of underwater lamps based on Light Emitting Diode (LED) technology (Fuah et al., 2025). This technology offers several advantages over conventional lamps. First, LEDs are well known for their much lower energy consumption. Second, LEDs can produce a light spectrum that is more compatible with the phototactic response of fish, making them more effective in attracting fish schools to the fishing area. Third, underwater LEDs can be positioned directly within the water column, allowing light intensity to be more focused and minimizing loss due to surface reflection (Rahayu et al., 2021). Several studies have shown that the use of underwater LEDs can increase catches by

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20–40% compared to conventional lamps. Thus, the application of underwater LEDs not only provides economic benefits for fishers but also supports the Sustainable Development Goals (SDGs), particularly Goal 14 (Life Below Water), which emphasizes the importance of conserving and sustainably utilizing marine resources.

Unfortunately, the adoption of underwater LED technology among traditional fishers in Aceh remains very limited. Limited access to information and training has been one of the main obstacles. Therefore, educational and mentoring programs are needed to provide fishers with comprehensive knowledge as well as practical skills. In this context, a community service team from the Faculty of Marine and Fisheries, Universitas Syiah Kuala, has taken the initiative to carry out an educational program on energy-efficient underwater LED technology in Gampong Lhok Layeun.

This educational activity is expected to provide several key benefits. First, to enhance fishers' knowledge about underwater LED technology, including installation, maintenance, and operating principles. Second, to provide practical skills so that fishers can independently operate the technology without relying on external assistance. Third, to encourage changes in attitudes and behavior among fishers so that they become more open to technological innovations.

Through this program, it is expected that lift net fishers in Aceh Besar will be able to increase their fishing productivity while simultaneously reducing operational costs. This article will provide a detailed description of the problem background, the methods of implementation, the results obtained, and the implications of applying energy-efficient underwater LED technology in supporting the sustainability of traditional fisheries.

## METHOD

This community service activity was carried out on Saturday, July 5, 2025, in Gampong Lhok Layeun, Leupung Sub-district, Aceh Besar District, Aceh Province. The location was chosen because the majority of the community works as traditional fishers, with with boat lift nets serving as their primary fishing gear. In addition, Lhok Layeun is one of the coastal villages that is actively engaged in maritime customary practices under the coordination of *Panglima Laot*, a traditional institution that plays an important role in regulating traditional fisheries management in Aceh.

The number of participants in this activity was 25, consisting of; fishers using lift net, *Panglima Laot* of Lhok Leupung, the *Geuchik* (village head) along with village officials, and Academics from Universitas Syiah Kuala. The method of implementation employed a participatory approach with a descriptive qualitative design. The participatory approach was chosen because it actively involves the community in every stage of the activity, starting from problem identification, solution formulation, to evaluation.

### 1. Preparation and Initial Survey

This stage began with the formation of an implementation team consisting of lecturers and students. The team then coordinated with the *Geuchik* (village head) and *Panglima Laot* as local authorities. This coordination was essential to obtain customary approval and social support from the community. The initial survey was conducted through direct field observations and in-depth interviews with fishers. The data collected included, the number of

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boat lift net fleets operating in Lhok Layeun, types of lamps used (halogen, *petromaks*, or mercury lamps), fuel consumption per night of operation, estimated average operational costs, types of fish caught and catch trends over the past five years, and fishers' perceptions of new technology. In addition, the team documented the technical condition of the *bagan perahu*, lamp installation positions, and generator usage mechanisms. These data served as the basis for designing outreach materials and simulations on the use of underwater LED lamps.

**2. Outreach Stage**

The outreach activity was conducted at the *Meunasah* (village hall) of Gampong Lhok Layeun to ensure accessibility for all participants. The outreach materials included, explanation of the working principle of underwater LED lamps, differences between LED and conventional light spectra, potential fuel savings, ecological impacts of using environmentally friendly technology, demonstration of LED lamp installation on lift net. The delivery method combined interactive presentations, educational videos, and open discussions. During the session, participants were given opportunities to ask questions, share experiences, and express concerns about the new technology.

**3. Discussion Stage**

The discussion was held after the outreach session in an open group format, moderated by the Academic Team from Universitas Syiah Kuala. The aim was to gain a deeper insight into fishers' views on the adoption of underwater LED technology. Discussion topics included the technical feasibility of installing LED lamps on lift nets, the potential for increased catches, cost comparisons between using generators and batteries/accumulators, anticipated challenges such as equipment costs and spare part availability, and the role of traditional institutions and village governments in supporting implementation.

From the fishermen's perspective, the adoption of underwater LED technology was viewed as promising but requiring several conditions to be met. They emphasized the need for practical training sessions focused on assembling and maintaining LED systems, as many fishers have limited technical experience. Additionally, they suggested that initial financial support or subsidies from local government or cooperatives would be essential to cover the high upfront costs of LED equipment. Fishers also highlighted the importance of ensuring reliable access to spare parts and batteries, preferably through local suppliers, to avoid delays during the fishing season.

Moreover, participants proposed that pilot testing should be conducted collaboratively with selected local fishers to observe real catch improvements and operational efficiency before large-scale adoption. They expressed optimism that if the technology proves to reduce fuel expenses and increase catch volume, it could become a sustainable alternative to generator-based lighting. Finally, the fishers urged that traditional institutions (such as Panglima Laot) and village authorities should be involved in coordination, socialization, and regulation to ensure fair use and knowledge sharing among community members.

**4. Evaluation and Monitoring Stage**

The evaluation stage was conducted using two approaches (Ahmad & Laha, 2020):

a) Pre-test and post-test: Participants were given quizzes before and after the outreach to measure knowledge improvement. Results showed an increase in the average score from 57 to 84.
b) Perception evaluation: Open interviews were conducted to assess participants' interest and readiness to adopt LED technology. Results indicated that 100% of participants were willing to try.

Meanwhile, monitoring was carried out by assisting fishers who began using LED lamps in their *bagan perahu* operations. The team observed equipment performance, fish species attracted to LED light, and technical challenges encountered. These monitoring data will serve as evaluation material for developing future programs. The four stages are illustrated in Figure 1 below.

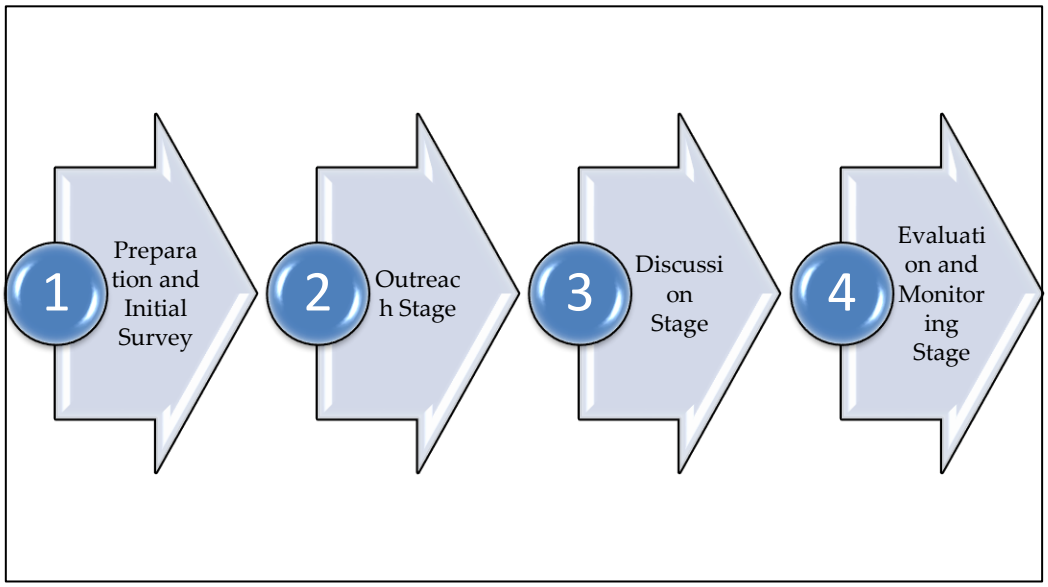


**Figure 1.** Stages of Community Service Implementation

**5. Reasons for Method Selection**

The participatory method was chosen because it is considered more effective in the context of empowering fishing communities. By actively involving the fishers, the technology adoption process goes beyond mere knowledge transfer and fosters a sense of ownership. In addition, the use of a descriptive qualitative method allows the team to gain a deeper understanding of the phenomenon, both from technical and socio-cultural aspects.

**6. Roles of Actors in the Activity**

1. Community Service Team (lecturers and students): Prepared materials, facilitated discussions, provided technical assistance, and conducted evaluations.
2. Panglima Laot: Acted as a mediator between the team and the fishing community, ensuring that activities aligned with customary maritime norms.
3. Geuchik and village officials: Provided administrative support and facilitated the venue for activities.
4. Fisher participants: Served as both subjects and active partners in the activities, contributing input based on field experience.

Thus, the methods applied in this activity were not only technical in nature but also strengthened social, institutional, and cultural aspects, thereby increasing the likelihood of program sustainability.

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## RESULT AND DISCUSSION

The community service activity with the theme "Education on Energy-Efficient Underwater Light Emitting Diode (LED) Technology for Boat Lift Net in Aceh Besar" was carried out with the participation of 25 individuals, consisting of boat lift net fishers, the *Panglima Laot*, the *Geuchik*, and academics. Overall, the program ran smoothly and was met with enthusiasm by the community. The outcomes of this activity can be presented based on the main stages of implementation, accompanied by an analytical discussion of the social, economic, and technical impacts of the program.

### 1. Preparation and Initial Survey Stage

The initial survey served as a crucial foundation for the program's success. The service team found that the majority of fishers in Lhok Layeun still relied on mercury or halogen lamps installed above the water's surface and powered by generators. On average, fuel consumption for lighting ranged from 5–10 liters per night, costing between USD 3.93-7,86. This created a heavy burden, especially when catches were declining.

From interviews, most fishers explained that conventional lamps had been used for decades. They were "accustomed" to the bright glow of mercury lamps, despite being aware of the high operational costs. Only a few had ever heard of underwater LED lamps, and even then, only from stories shared by fellow fishers in other regions. A survey, in this context, refers to research conducted by collecting information from a sample through questionnaires or interviews in order to describe various aspects of a population (Maidiana, 2021).

These survey findings highlighted a significant knowledge gap between advancements in fisheries technology and the awareness of local fishers. This gap was precisely what the program aimed to bridge through education. Methodologically, this aligns with Rogers' (2003) Diffusion of Innovations theory, which emphasizes that innovation adoption is influenced by five stages: knowledge, persuasion, decision, implementation, and confirmation. Fishers in Lhok Layeun were still in the very early "knowledge stage," with extremely limited exposure (Figure 2).

**Figure 2.** Initial survey meeting with the *Panglima Laot* of Lhok Leupung

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This stage served as the foundation for the success of the entire community service program, as the data collected here determined the relevance of outreach materials, the design of demonstrations, and the evaluation indicators. The detailed steps are presented in Table 1.

**Table 1.** Detailed Steps of the Preparation/Initial Survey Stage

| No | Step | | Activity Description |
|---|---|---|---|
| 1 | Team formation and role distribution | 1 | Appointing a field coordinator, enumerators, documenters, and a liaison to the village officials. |
| | | 2 | Preparing a daily work plan. |
| 2 | Coordination with Stakeholders | 1 | Initial audience with the *Geuchik* of Lhok Layeun, the *Panglima Laot*, and representatives of the fishers |
| | | 2 | Presenting the purpose, benefits, and schedule of activities; requesting an endorsement letter and customary approval |
| 3 | Survey Instrument Design | 1 | Collecting data on fleet identity, types of lamps, fuel consumption, and average catches |
| | | 2 | Gathering fishers' perceptions of new technology, economic challenges, and expectations |
| | | 3 | Documenting boat design, lamp placement, energy sources, and battery/generator conditions |
| | | 4 | Visual documentation |
| 4 | Determination of Outreach Materials | 1 | Aligning fishers' needs (fuel savings, lamp durability) with LED presentation content |
| | | 2 | Designing field demonstrations based on findings: light spectrum, installation methods, and savings calculations |

**2. Socialization Stage**

The socialization activity was carried out in the form of presentations and the screening of educational videos about the working principles and advantages of underwater LED technology. Socialization can be understood as a learning process in which members of a community come to know and internalize norms and values, leading to the shaping of attitudes (Dananier & Rahmadhani, 2024). Participants demonstrated high enthusiasm, engaging in interactive Q&A sessions regarding energy sources, device durability, and the potential for increasing fish catches. This stage served as a medium for information delivery and initial education about energy-efficient Underwater Light Emitting Diode (LED) technology for the fishing community and stakeholders in Gampong Lhok Layeun. The activity was held at the *Meunasah* (village hall) and attended by 25 participants, consisting of lift-net fishers, the *Panglima Laot* of Lhok Leupung, academics, and the *Geuchik* of Lhok Layeun.

The objectives of the socialization activity were to:

a) Introduce the working principles of efficient and environmentally friendly underwater LED lights.
b) Present initial survey results regarding fishers' use of conventional lighting and their energy needs.
c) Build awareness of the benefits of adopting this technology in terms of operational efficiency and sustainable fishery resources.

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The socialization was carried out through interactive presentations, educational video screenings, and open discussions. Both Indonesian and Acehnese languages were used to ensure the message was fully understood by all participants. The materials presented included:

a) A comparison between LED and conventional lamps in terms of energy consumption, light spectrum, and durability.
b) Economic aspects, such as fuel savings, extended operational hours, and reduced production costs.
c) Technical guidance, including installation procedures, light intensity adjustment, and the use of batteries/accumulators.
d) Environmental aspects, highlighting cleaner energy use and the positive impacts on the sustainability of small pelagic fish resources (Figure 3).

During the activity, participants responded with great enthusiasm. Most of them actively raised questions, especially regarding how LED works at certain depths, the range of light underwater, and which fish species respond most effectively to particular light spectra. Additionally, participants expressed concerns about the availability of spare parts and protection against short circuits when used at sea.

As a result, 100% of participants declared their interest in trying the underwater LED technology once the prototype was introduced in the following trial activity. The outcomes of this stage included: increased understanding among participants about energy efficiency and the economic benefits of underwater LED use; a collective commitment from fishers to conduct independent trials during fishing operations with technical support from the implementing team; and the *Panglima Laot* expressing readiness to act as a community liaison should further training be required.

**Figure 3.** Stages of Material Socialization to Boat Lift Net Fishers in Lhok Layeun

**3. Discussion Stage**

The group discussion was facilitated by the implementation team together with the *Panglima Laot* and academics. Discussion can be defined as a two-way or multi-directional form of communication, conducted either orally or in writing, with the purpose of exchanging ideas, opinions, information, or solutions to a particular issue (Sulistyaningsih et al. 2017). The

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results of the discussion highlighted the importance of collaboration between educational institutions, the village government, and fishing groups in promoting the adoption of environmentally friendly and cost-efficient technologies. The discussion stage was carried out after the socialization activity as an effort to explore more deeply the perceptions, experiences, and expectations of participants regarding the application of energy-saving underwater LED technology in boat lift net fishing operations (Figure 4).

This discussion also served as a reflective space that enabled the exchange of ideas between fishers, traditional leaders, village government officials, and academics. The objectives of the discussion were:

a) To gain deeper insights into fishers' responses and concerns regarding the use of underwater LED technology at sea.
b) To gather suggestions and input from local stakeholders on plans for further implementation.
c) To foster a sense of ownership among fishers toward the introduced technological innovation.

**Figure 4.** Discussion with Participants in the Community Service Activity

The discussion was conducted in a group format with a moderator from the implementation team, facilitated by the *Panglima Laot* and the *Geuchik* of Gampong Lhok Layeun as local mediators. The topics discussed included:

a) Technical and operational challenges of using the lights at sea.
b) Economic factors and affordability of the equipment.
c) Potential impacts on fish catch and the environment.
d) Social and institutional support for the sustainability of the technology.

The results of the discussion are presented in Table 2 below.

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**Table 2.** Results of the discussion in the community service activity

| No | Topic | Participants' Responses/Opinions |
|---|---|---|
| 1 | Efficiency and Performance | Most participants believe that LEDs are more efficient but still require proof through routine trials of at least one month |
| 2 | Price and Accessibility | The cost of the equipment is the main concern. Participants hope that the developed prototype will be affordable, easy to obtain, and widely adoptable |
| 3 | Maintenance | Participants suggested direct training on prototype production for fishers so that the equipment can be maintained independently without external dependence |
| 4 | Impact on Catch Results | Long-term comparative data is needed. Participants want to know which fish species are most responsive to LED light |
| 5 | Role of Traditional and Village Institutions | The *Panglima Laot* and *Geuchik* expressed their readiness to support the sustainability of this initiative |

**5. Evaluation and Monitoring Stage**

The evaluation and monitoring stage was carried out to assess the effectiveness of the community service activities, evaluate the participants' level of understanding of the delivered material, and monitor the initial implementation of underwater LED technology by *bagan perahu* fishers directly in the field. Monitoring and evaluation activities include planning, data collection on program implementation, activity reporting, and performance assessment (Hutauruk et al., 2022).

The evaluation also aimed to identify strengths, weaknesses, and opportunities for future program development. Two main approaches were applied:

a) Cognitive Evaluation (Pre-Post Test): Participants were given a short quiz before and after the socialization session to measure improvements in understanding of the principles and benefits of underwater LED lighting.
b) Perception Evaluation (Interviews): Conducted openly to assess participants' perceptions, interest, and readiness to adopt the underwater LED technology.

The summary of evaluation results based on these instruments is presented in Table 3.

**Table 3.** Results of the Community Service Evaluation Activities

| No | Evaluation Aspect | Findings |
|---|---|---|
| 1 | Improvement in Understanding | The participants' average score increased from 57 (before socialization) to 84 (after socialization), indicating an improvement of approximately 47%. |
| 2 | Interest in Adopting the Technology | 100% of participants expressed their willingness to try the underwater LED technology |
| 3 | Quality of Activity Implementation | 100% of participants stated they were satisfied with the material delivery, equipment demonstration, and discussion methods used |

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**6. Socio-Economic Impact Analysis**

From an economic perspective, the use of LED lights has the potential to significantly reduce operational costs. If LEDs can cut fuel consumption by up to 50%, fishers could save around IDR 30,000–60,000 per night of operation. Over the course of a month (±20 fishing trips), the savings could reach IDR 600,000–1,200,000. This amount is highly meaningful for small-scale fishers.

From a social perspective, this activity successfully enhanced the capacity of fishing communities to embrace technological innovation. The active participation of fishers, combined with institutional support from the *Panglima Laot*, serves as a positive indicator that the program can continue independently. From an environmental perspective, LED technology is more eco-friendly as it reduces light pollution on the sea surface and lowers carbon emissions by decreasing fossil fuel consumption. This aligns with the sustainable development agenda in the fisheries sector.

**6. Theoretical Discussion**

The field findings can be analyzed using the Diffusion of Innovation (DOI) framework proposed by Rogers (2003). This theory explains how new ideas and technologies spread through a community or social system over time, influenced by factors such as relative advantage, compatibility, complexity, trialability, and observability. In the context of this study, several factors were identified as drivers of the adoption of underwater LED technology by fishers. First, LEDs are more energy- and cost-efficient compared to traditional lighting using generators, offering a clear *relative advantage*. Second, the technology shows strong *compatibility* with the operational characteristics of lift net fishing, as it can be easily integrated without major modification of existing gear. Third, the *simplicity* of LED operation makes it accessible to fishers with limited technical experience. Fourth, the *trialability* of the innovation is high, as fishers can test LED prototypes directly during fishing activities. Finally, the *observability* aspect is evident through visible increases in the number of fish attracted to the light source, strengthening fishers' confidence in the technology's effectiveness.

However, the success of LED adoption also depends on supporting conditions. Based on field feedback, continuous technical assistance, affordable access to spare parts, and financial support for initial equipment procurement are key determinants of successful implementation. If these elements are ensured, the diffusion process is likely to reach the *adoption* and *confirmation* stages successfully, leading to sustained use and potential scaling-up among other coastal communities. Conversely, failure of adoption may occur if the LED design remains too costly, technically fragile, or lacks local support mechanisms. Fishers expressed concern that without local training and maintenance capacity, they may revert to conventional lighting due to convenience and reliability. Therefore, the main suggestion from this study is to develop a more durable and locally serviceable LED prototype, supported by a participatory training program that enables fishers to assemble, maintain, and troubleshoot the system independently. This approach not only increases the likelihood of successful innovation adoption, but also strengthens local ownership and long-term sustainability of the LED technology in small-scale fisheries.

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### 7. Synthesis of Results and Implications

Overall, this activity successfully achieved its main goal: to increase the knowledge, skills, and interest of fishers in adopting energy-efficient underwater LED technology. The enthusiasm of participants shows that this innovation has great potential for wider implementation. The implication is that the success of this program can serve as a model of community service based on appropriate technology that can be replicated in other regions. Furthermore, this program makes a tangible contribution to the achievement of the Sustainable Development Goals (SDGs), particularly Goal 1 (No Poverty), Goal 7 (Affordable and Clean Energy), and Goal 14 (Life Below Water).

## CONCLUSION

The community service program carried out in Gampong Lhok Layeun, Leupung Subdistrict, Aceh Besar, successfully enhanced the understanding and interest of *bagan perahu* fishers in adopting energy-efficient underwater LED technology. The program also received positive responses regarding the delivery methods, interactive discussions, and live equipment demonstrations.

For program sustainability, it is recommended to conduct extended field trials to thoroughly assess the effectiveness of underwater LED technology in relation to target fish species, catch efficiency, and environmental impacts. In addition, training on independent production and maintenance of the equipment should be provided so that fishers will not be dependent on external parties.

Furthermore, future initiatives should emphasize capacity building for fishers, including strengthening their technical skills, management capabilities, and digital literacy related to modern fishing technologies. Empowering fishers in these aspects will enhance their adaptability, improve decision-making in fishing operations, and contribute to sustainable coastal resource management.

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