EMPOWERING COASTAL COMMUNITIES BY ENHANCING FISHERMEN'S PRODUCTIVITY AND MICRO-ENTERPRISE DEVELOPMENT THROUGH TECHNOLOGY AND INNOVATION

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Keywords:
Multicolor LED technology, GNSS, marine product processing, community empowerment, digital marketing

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Abstract: In Lobuk Village, Sumenep Regency, a community empowerment program was carried out which focused on improving the welfare of traditional fishermen and developing micro-enterprises based on marine products. The angghas fishermen, part of the Pokdarwis (*Kelompok Sadar Wisata*), face challenges in low productivity due to limited technology. Meanwhile, BUMDes Pelangi Nusantara business unit encounters issues in product quality and limited market reach for processed marine products. To increase fish catches, the solution implemented in this program is the use of multicolor LED lighting technology and low-cost GNSS devices. To overcome the constraints of BUMDes Pelangi Nusantara, improvements were made to production technology, such as modern equipment, food grade packaging design training, and digital marketing development. The implementation of this solution provided initial results in the form of an 80% increase in fishermen's productivity in terms of the quality and quantity of fish catch. GNSS technology enabled more effective catch spacing, reducing competition among fishermen. For BUMDes, product quality improvements reached 70%, accompanied by expanded market reach through digital platforms. The results of this program are in the form of improving community skills and documentation. This program demonstrates that appropriate technology implementation and community-based innovation can drive the economic sustainability of coastal communities.

INTRODUCTION

Lobuk Village is one of the villages in Bluto Subdistrict, Sumenep Regency, East Java Province, located 15 kilometers from the city of Sumenep. This village is classified as an independent village and in 2021 achieved 4th place as the best village in East Java, as stated in the Governor of East Java's Decree Number 188/466/KPTS/013/2021. Most of the residents of Lobuk Village, totaling 1,960 people or 43.05% of the total population, work as fishermen.

Despite being an independent village, Lobuk Village still faces poverty problems. According to BPS Sumenep Regency data (2023), 503 households are classified as poor. Most of these poor households are small-scale fishermen who rely on fish catches using angghas. Angghas is a traditional fish-catching tool resembling a small angghas with a rumpon measuring 2 x 1.5 meters, which serves as a gathering spot for fish to facilitate catching.

(a) (b) (c)

Figure 1. (a) Small Rumpon (b) Buoy for Placing Light Source (c) Positioning Angghas using GNSS Technology

To improve the welfare of fishermen, the village government established the Tourism Awareness Group (Pokdarwis), which utilizes angghas around Matahari Beach as fishing spots for tourists. Currently, there are 25 angghas fishermen who are members of Pokdarwis. However, the utilization of angghas as a fishing and tourism tool still has limitations. During the day, angghas are used as fishing spots for tourists, while at night, they are used by fishermen to catch fish. Nevertheless, the catches are still suboptimal due to the simple tools used. To increase the added value, BUMDes Pelangi Nusantara Lobuk processes fish catches into products such as crispy fish, which have begun to receive positive responses from consumers. However, the processing and marketing processes are still carried out simply, resulting in limited market reach.

GNSS has been widely used in various applications such as navigation (Cahyadi et al, 2022; Cahyadi et al, 2023), ionosphere (Cahyadi et al, 2020; Cahyadi et al, 2021; Cahyadi et al, 2022), and troposphere (Cahyadi et al, 2024), offering the potential to support the management of fishing gear in Lobuk Village. The application of this technology is expected

to be an innovative solution for fishermen to optimize the use of fishing gear to ensure the accuracy of the fishing position.

This research focuses on implementing innovative technologies such as multicolor LED lights to improve the efficiency of fish catches and low-cost GNSS devices for managing fishing tools. Additionally, modern technologies such as deep fryers and spinners are used to enhance the quality of processed fish products. This approach is expected to increase fishermen's productivity, improve product quality, and expand markets through digital marketing strategies.

RESEARCH METHODS

This research is designed to increase the catch of fishermen in Lobuk Village through the application of innovative technology with the development of integration of underwater multicolor LED lights and Low-cost GNSS. Underwater Multicolor LED Lights are designed with a light spectrum that can attract fish with three variation of range. Red color LED is used to attract fish in only short ranges, green for medium ranges, and blue for longer ranges. These LED lights are installed underwater in order to ensure even distribution of light in the sea area at night time. Its operation uses energy-efficient batteries and does not produce noise, making it efficient and environmentally friendly.

Efficiency in monitoring the location of the angghas installation is done through the Low-cost GNSS device developed that is placed on it. This Low-cost GNSS uses a U-Blox F9-based sensor that has high accuracy with a Real-Time Kinematic (RTK) error rate of ±1 cm. This device also equipped with Bluetooth connectivity capabilities, so that it can do the integration with smart devices, such as smartphones and laptops. This technology allows fishermen to map the location of angghas in real-time and ensure optimal positioning for maximum fish catch results. The following are the specifications of the Low-cost GNSS device.

Table 1. Low-Cost GNSS (SMART GEO PD ITS) (U-blox, 2023)

Kategori	Detail
Receiver Type	1. 184-Channel U-Blox F9 engine.
	2. GPS L1C/A, L2C, GLO L1OF, L2OF, GAL E1B/C, E5B, BDS B1I, B2I, QZSS L1C/A, L1S, L2C, SBAS L1C/A.
Update Rate	RTK up to 20 Hz.

Position Accuracy	RTK 0.01 m + 1 ppm CEP.
Convergence Time	RTK < 10 sec.
Sensitivity	1. Tracking & Navigation: -167 dBm.
	2. Cold Starts: -148 dBm.
	3. Hot Starts: -157 dBm.
	4. Reacquisition: -160 dBm.
Connectivity	Bluetooth system for connecting between smartphone and GPS device.
Battery	Using a rechargeable battery that does not make any noise.

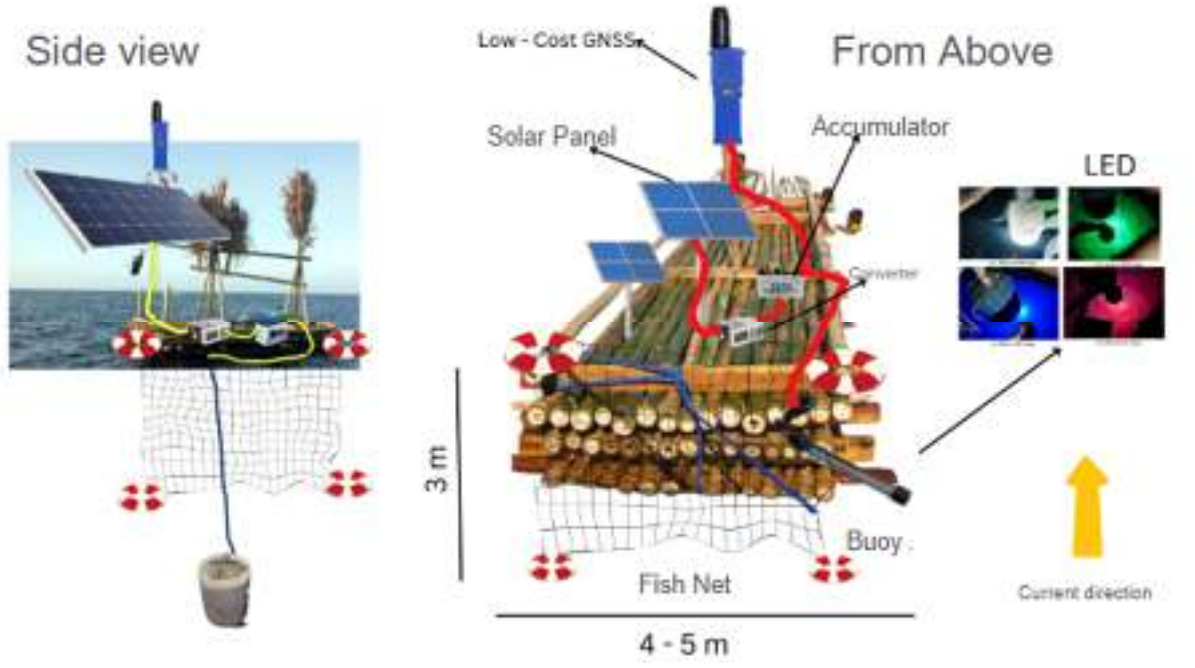

Figure 2. Technology Component Installation

The main components in this research involve underwater multicolor LED lights, GNSS devices, solar panels, batteries, converters, and nets and buoys that support the angghas structure. Multicolor LED lights are installed under the water surface on the angghas structure made of bamboo or wood which is strong enough. The position of the lights is designed to emit light to the entire area around the angghas. These lights are assembled with transparent acrylic

tubes to protect them from corrosion due to seawater and ensure the connections to the cables are watertight using special sealants also to protect it from any damage possible underwater.

A net system is installed around the angghas which is used to trap fish attracted to the LED lights. Buoys are used to maintain the stability and position of the angghas so that it remains in a strategic place according to the ocean currents. At the top of the angghas, a Low-cost GNSS device is installed on the main mast. This Low-cost GNSS is equipped with an antenna connected to a Bluetooth-based electronic device that allows fishermen to monitor the location of the angghas in real-time via their smartphones. So that they can navigate the location easily.

The system resources of energy come from solar panels installed on the angghas structure to maximize the absorption of sunlight throughout the day. The collected energy is stored in a battery that is directly connected to the converter system. This converter functions to channel power to LED lights and GNSS devices according to operational needs. The use of solar panels allows the device to operate continuously without relying on fossil fuels, making it more environmentally friendly. In addition, angghas can operate all night without interruption, and continue to attract the fish at night. The navigation system on this angghas will help fishermen to track dangerous locations. Thus, fishermen can avoid these dangerous areas anytime

RESULTS AND DISCUSSION

To increase the catch of fishermen in Lobuk village, this study created an innovative tool in the form of a low-cost GNSS tool and multicolor LED equipped with solar cells that are expected to be rechargeable and used for a longer period of time without requiring additional resources. The integration of low-cost GNSS and multicolor LEDs is expected to not only help fishermen to increase their fish catch but also provide additional security by allowing real-time position tracking and avoiding dangerous areas. This tool is designed to be environmentally friendly and economical, making this innovation a practical solution for fishermen in Lobuk Village. An image of the multicolor LED can be seen in Figure 3 below.

Figure 3. Multi-Color LED light (a) Red LED (b) Green LED
(c) When installed in a anggas structure

Fish have phototaxis properties, which are attracted to light, which makes it a natural adaptation process to support their survival (Jones et al., 2004, Yu et al., 2022). The innovation of multicolor LED lights comes with the ability to adjust the intensity and spectrum of light, so this innovation can be very effective in manipulating fish behavior (Yu et al., 2022). In addition to influencing the social behavior of fish at night such as gathering or increasing reproductive activity, LED lights can also make it easier for fish to find their food. In addition, the availability of this underwater multicolor LED light will help fishermen to see the number of fish groups that gather to determine whether they are ready to be caught.

- Improvement in Micro-Enterprise Development

The adoption of innovative fishing technologies, such as Low-Cost GNSS and Multicolor LED systems, has greatly benefited the micro-enterprise operations of BUMDes Pelangi Nusantara in Lobuk Village. These advancements have effectively tackled persistent issues in fish processing and market growth, resulting in notable enhancements in product quality, operational efficiency, and market accessibility.

The use of GNSS and LED technologies has consistently boosted fish catches, giving BUMDes a dependable source of high-quality raw materials. This reliable supply has paved the way for the enterprise to shift towards value-added production by incorporating modern equipment into their operations. Equipment like deep fryers, spinners, and vacuum sealers has transformed traditional fish processing by improving efficiency and standardization. The deep fryer guarantees hygienic cooking of fish products, while the spinner enhances texture by removing excess oil, which also helps extend shelf life. In addition, vacuum packaging machines are essential for maintaining freshness and preventing contamination, thus ensuring compliance with food safety standards. These upgrades have resulted in a 70% improvement in product quality, enabling these products to compete successfully in larger markets

Digital marketing has transformed business. By having a website and being active on social media, BUMDes has reached more customers beyond the local area. These digital platforms provide product information and make it easier for customers to buy. This transition has resulted in a huge increase in sales, with weekly figures increasing from 10-20 units to 30-50 units, marking a growth of 150%. This highlights the important role of digital marketing in bridging small-scale producers with a wider audience.

The advent of digital financial management tools such as Kasir Mini Pro has facilitated more efficient money management for micro-enterprises. This enables them to gain insight into their expenditure and inventory, thereby empowering them to make more informed decisions about the direction of their business. Additionally, it fosters a sense of reliability and transparency, which are crucial for fostering mutually beneficial relationships with stakeholders.

These innovations help the Lobuk community as a whole, not just the micro-enterprise. More jobs have been created because more fish is being produced and sold. Training has been provided to local residents so they can use modern equipment and digital tools. This has helped many families in the village to live better.

This initiative's utilization of solar panels demonstrates its environmental responsibility. It promotes economic expansion and is consistent with more general environmental objectives.

CONCLUSIONS AND RECOMMENDATION

Fishermen in Lobuk Village get benefits in community empowerment programs to improve the welfare of the indigenous people of Lobuk Village, Sumenep Regency. The micro business of Lobuk Village also receives benefits by processing fishermen's fish catches to try to be more distributed outside the city to outside the island through digitalization marketing through the website.

Marketing training is a program to implement marine products up to 70% to the benefit of the community, by using a collaborative and participatory approach to ensure active community involvement, leading to skill improvement, visual documentation, and scientific publications. The program highlights the importance of the right application of technology and community-based innovation in promoting the economic sustainability of coastal communities, with the potential to be replicated in other coastal areas.

Designing a specialized framework to fulfill programs for each community, accompanied by ongoing guidance in the knowledge of creating multicolor LED systems and fish-based product processing utilizing technology and digital platforms. Other coastal programs should also be implemented, such as training to enhance coastal tourism for both international and domestic tourists.

ACKNOWLEDGEMENTS

The authors are grateful for the financial support provided by the KOSABANGSA 2024 for this study (Grant Agreement Nos. 011/E5/P6.02.00/KOSABANGSA/2024; 002/SP2H/KOSABANGSA/LL7/2024; 115/LPPM/PP-04/E.02/2024).

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