

## EMPOWERING COASTAL COMMUNITIES THROUGH REVITALIZATION OF THE LEMBUNG MANGROVE ECOTOURISM AREA IN LEMBUNG VILLAGE, GALIS DISTRICT, PAMEKASAN REGENCY

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### Abstract

Mangrove forests play a vital role in protecting coastal areas. They regulate hydrological functions and prevent natural disasters. At the same time, these ecosystems support biodiversity, provide habitat for fish, crustaceans, and birds, and support the livelihoods of local residents. In Lembung Village, Galis District, Pamekasan Regency, community service workers from the State Polytechnic of Malang, along with the “Sabuk Hijau” tourism awareness group, are expanding mangrove revegetation efforts to strengthen their coastline while creating sustainable livelihoods through silvofishery and the introduction of fish processing technology. Silvofishery itself is a system that combines mangrove forest conservation with mangrove crab cultivation, while fish processing technology is introduced to utilize the abundant fish available locally for sale in dried form. The purpose of this community service is to implement mangrove conservation in synergy with silvofishery, thus providing ecological, social, and economic benefits for the local community, preserving natural resources, and strengthening the ecotourism-based economy of coastal communities through the introduction of fish processing technology. The results of this community service include revegetation of one hectare of mangrove forest, construction of a silvofishery area, and a fish drying machine.

**Keywords:** Costal Area, Mangrove Revegetation, Silvofishery, Fish Drying, Ecotourism

### INTRODUCTION

Ecotourism is a form of tourism that responsibly conserves nature, empowers local communities, and provides environmentally and culturally based travel experiences (Enggita and Wulandari, 2024). In recent decades, global tourism trends have shifted toward more sustainable and responsible forms of travel, along with increasing awareness of environmental issues, climate change, and the importance of biodiversity conservation (Ashok et al., 2022).

The coastal area of Lembung Village, Galis District, Pamekasan Regency, is rich in biodiversity and holds significant ecological, economic, and socio-cultural value. Ecosystems such as mangrove forests and the presence of coastal and marine flora and fauna are major

attractions with significant potential for development as ecotourism destinations. However, the coastal area of Lembung Village currently faces various serious challenges, such as environmental degradation due to human activities, climate change, overexploitation of natural resources, and land conversion. Unsustainably managed ecotourism activities can also worsen environmental conditions and threaten the sustainability of coastal ecosystems (Baloch et al., 2023).

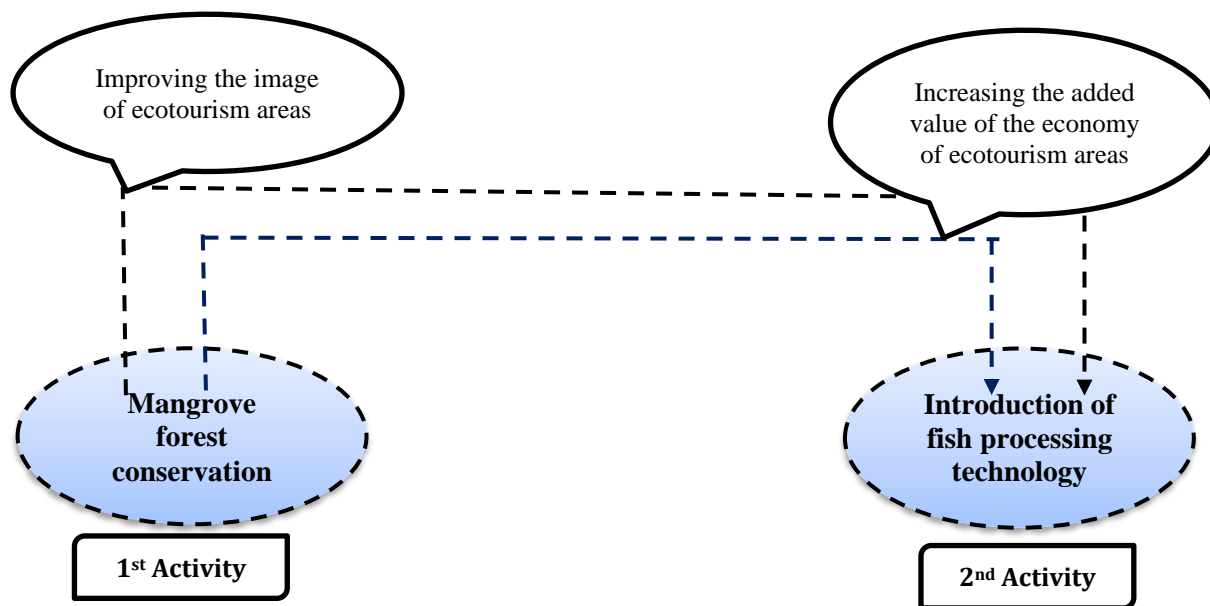
Strengthening ecotourism activities aimed at empowering coastal communities economically is a strategic step to address these challenges. By applying ecotourism principles: conservation, education, community participation, and economic sustainability, coastal ecotourism development can be directed towards supporting environmental conservation while improving the well-being of local communities (Stojanović et al., 2021). Furthermore, these activities can also serve as an educational platform for ecotourists and communities about the importance of preserving coastal and marine areas.

This strengthening encompasses various aspects, such as increasing the capacity of coastal communities to manage ecotourism potential, developing environmentally conscious ecotourism area governance, developing environmentally friendly infrastructure, and promoting responsible ecotourism. Thus, coastal areas become not only tourist attractions but also sustainable conservation areas and sources of sustainable livelihoods (Widayanto and Nurrahma, 2022).

## **IMPLEMENTATION METHOD**

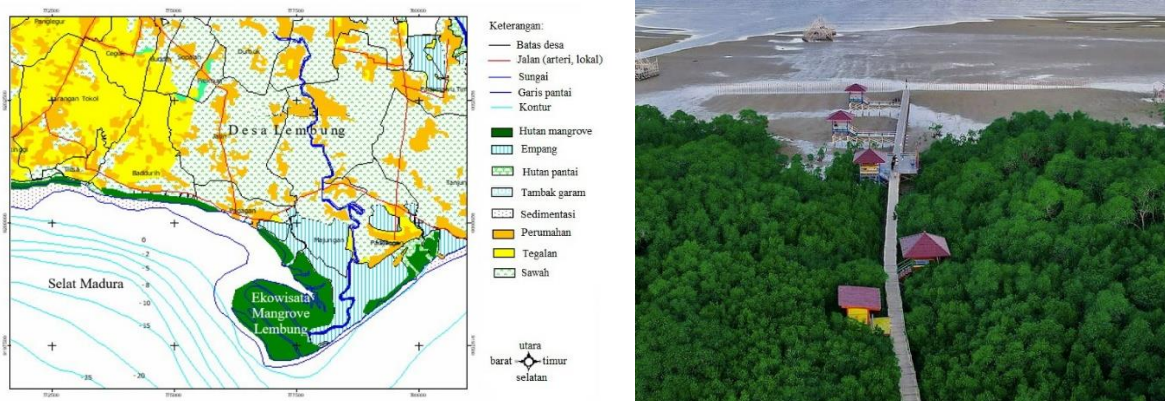
Empowerment of coastal communities in the "Lembung Mangrove Ecotourism" area is being carried out through revitalization to support the livelihoods and well-being of local residents. Activities undertaken include "mangrove forest conservation," which can be synergized with the "introduction of fish processing technology" (Fig. 1). The community service program is being implemented by volunteers from the Malang State Polytechnic (Polinema), the "Sabel Hijau" tourism awareness group (Pokdarwis), and the Lembung village government.

The coastal waters of Lembung Village, directly adjacent to the Madura Strait (Fig. 2), have a muddy bottom with moderate waves. The coastline is home to a growing mangrove community. The variety of substrates along the coast allows for a high diversity of species, both as ecosystem types and as flora and fauna. The varied topography and position relative to sea level, which results in variations in inundation intensity, and the complex influence of salinity across various locations, also create a number of distinct, specific conditions. This ultimately can be seen as a unique characteristic of the mangroves in Lembung Village.



**Figure 1. Community partnership program in Lembung mangrove ecotourism**

The mangrove forest ecosystem (Fig. 2) contains great potential that can support the fulfillment of the living needs of the people in Lembung Village, both as a source of wood, fisheries and other needs. The natural functions of mangrove forests (Mattone and Sheaves, 2024) as: (1) regulators of hydrological functions, (2) prevention of natural disasters, (3) guardians of natural systems and processes, and (3) protection and nutrition, its sustainability is important to maintain. Mangrove conservation is essentially maintaining these functions by also utilizing them rationally with an environmental perspective.



**Figure 2. Mangrove forest in Lembung village, Galis, Pamekasan**

One approach that can be implemented to ensure both the functional and economic importance of mangroves is aquaculture using the silvofishery system. The basic principle of this cultivation system is the dual use of mangroves, which aligns their ecosystem functions: biological, ecological, and economic. Various types of economically viable biota can be cultivated in mangrove areas using the silvofishery system, including the cultivation of mangrove crabs (*Scylla* sp.). Mangrove crabs are one of the aquatic biota in mangrove areas with high economic value (Budijono et al., 2021).

Pamekasan Regency has the potential for various types of fishery products (capture, cultivation, and aquaculture). Marine fisheries production in Pamekasan Regency reached 19,554.1 tons in 2020, contributing 21% of the total fishery production volume on Madura Island. Fisheries production in Galis District reached 591.5 tons (Bolkiah et al., 2021). In addition to fresh fish products, dried fish processing is a mainstay source of income for coastal communities in Lembung Village, Galis District, Pamekasan Regency. The conventional method of drying fish involves direct sun exposure. This method is time-consuming, requires a large area, is unhygienic, and is subject to seasonal fluctuations, which can impact production capacity. Therefore, the introduction of mechanical fish drying technology is necessary.

## RESULTS AND DISCUSSION

Mangrove forest revegetation aims not only to restore the primary ecological function of the mangrove ecosystem but also to strengthen the image of the ecotourism area. To support successful mangrove revegetation, it is necessary to consider the ecological conditions and site status. Therefore, it is necessary to understand the limiting factors on the coastal land, such as salinity levels and sediment substrate, to determine the type and design of revegetation. In mangrove areas, the presence of mud or sand deposits is an important physical factor for plant growth. However, optimal growth generally occurs on a muddy base substrate. On the sandy coastal land of Lembung Village, vegetation is selected that can break winds, adapt to marginal sites, tolerate salinity and drought, have deep roots, and form dense and tall vegetation (Rochmayanto et al., 2023).

In the community service activities by Polinema community members, they carried out technical procedures for planning and implementing mangrove revegetation. There are four steps that have been carried out in the technical procedures that support the success of mangrove revegetation, namely: (1) knowing the autecology, (2) observing the normal hydrological patterns of mangrove species in-situ, (3) paying attention to changes in the mangrove environment that hinder natural regeneration, and (4) planting mangrove seedlings on site.

**Table 1. Three mangrove species in the Lembung Mangrove Ecotourism**

Species	Seed Type	Month	Signs of Maturity	Size of Ripe Mangrove
<i>Rhizophora stylosa</i>	Propagule	S, O, N, D	Reddish stalk, brown seeds	Length > 50 cm
<i>Sonneratia alba</i>	Pagatpat	A, M, J, S, O	Floating in sea water	Diameter > 4 cm
<i>Avicenna marina</i>	Propagule	D, J, F	Yellow fruit skin	Weight > 30 gr

Mangrove seedlings should be planted after these three steps have been completed. This aims to ensure that the growth of the mangrove seedlings is as expected. Based on this condition, approximately 6,000 mangrove seedlings have been planted consisting of 3 mangrove species (Table 1) in the Lembung Mangrove Ecotourism (Fig. 3), namely: (1) *Rhizophora stylosa*, (2) *Sonneratia alba*, and (3) *Avicennia marina* on an area of 1 hectare.



**Figure 3. Planting mangrove seedlings**



**Figure 4. Silvofishery pond construction for mangrove crab cultivation**

The mangrove ecosystem plays a role as a combination of physical and biological aspects, known as ecological function. Meanwhile, utilization will be meaningful in the economic aspect where humans are one of the main elements that play a role as users of this ecosystem. One alternative utilization is to cultivate fisheries with a silvofishery system (Triyanto et al, 2012). Silvofishery is a concept in coastal resource management that integrates mangrove conservation with brackish water cultivation. Armed with data on normal hydrological patterns (time, depth, and duration of water inundation), the Polinema community service team together with Pokdarwis "Sabel Hijau" established a mangrove crab cultivation at the Lembung Mangrove Ecotourism site (Fig. 4). The aim of the activity is to create sustainable livelihoods through silvofishery, a system that combines mangrove forest conservation with mangrove crab cultivation.

After the construction of the silvofishery cultivation pond was completed, the Polinema community service team introduced 600 mangrove crab seeds measuring 50 – 100 grams/crab.

Mangrove crab cultivation is suitable for mangrove areas because (1) this ecosystem is indeed its natural habitat, (2) the availability of natural food such as mollusks, worms, small fish, and organic materials from fallen mangrove leaves, (3) Water conditions are more stable because mangroves help maintain seawater quality, (4) Protection from waves and predators because mangrove plants dampen currents and waves and their root structures also serve as hiding places for crabs from predators, and (5) have many high economic values (Saragi and Desrita, 2018).

Mangroves function beyond protecting coastlines; they also serve as habitats for aquatic biota, feeding grounds for marine life, and as breeding grounds for marine fish (Hutchison et al., 2014). These benefits make the mangrove ecosystem a significant potential source for the fisheries sector. In addition to fresh fish products, dried fish is a major source of fishery catches traded and consumed. Dried fish products are a core component of production, trade, diets, and cuisine worldwide (Belton et al., 2022), particularly on Madura Island.



(a) Parts of fish dehydrator machine      (b) Demo and training of fish dehydrator machine  
 Caption of (a): (1) Fish processing room, (2) charcoal filter, (3) door, (4) biomass container, (5) gas stove, (6) solenoid valve, (7) caster wheel, (8) blower, (9) control panel, (10) hot air pipe, (11) fish container, (12) combustion chamber

**Figure 5. Fish dehydrator machine**

Dried fish, here defined as aquatic animals preserved using a drying technique using a mechanical fish dehydrator machine (Fig. 5a), allows for long-term storage as food at room temperature without special packaging. This is done because the dried fish production sector provides employment for many people in the Lembung Mangrove Ecotourism area. The fish processing practice was attended by 40 members of the Pokdarwis "Sabuk Hijau" community (Fig. 5b) located around the Lembung Mangrove Ecotourism area. The Polinema community service team provided training related to fish processing, including smoking and drying fish.

Fish drying is a method of reducing the water content of fish through the use of heat energy to a level that prevents microorganisms from growing. Proper fish drying begins with the following steps.

- a. Selection of raw materials. Fish must be clean, free from any odors indicating decay, muddy odor, and other natural characteristics that can reduce quality and not endanger health (SNI-01-2729-1-1992);
- b. Cleaning and washing. The cleaning stage involves removing the guts, scales, and gills, as these are sources of bacterial contamination that can accelerate the decay process in raw

- materials. Washing is carried out using running water to remove dirt adhering to the surface of the skin and reduce the number of microorganisms;
- c. Draining. The washed fish are neatly arranged with the belly facing down, then drained to remove any remaining water. Draining is carried out until the remaining water no longer drips. This is done to ensure the drying process produces high-quality dried fish; and
  - d. Drying, packaging, and storage. The next stage is the drying, packaging, and storage in the product display (Fig. 6).



**Figure 6. The resulting drying product**

The fish processing technology introduced to the tourism awareness group (Pokdarwis) "Sabuk Hijau" partners has produced dried and smoked fish (Fig. 6-a, b). The resulting products have been displayed (Fig. 6-c) as souvenirs for ecotourists visiting the site. Polinema's community service activities through the introduction of fish processing technology have benefited community empowerment and local economic development through the sale of processed seafood products in the form of dried and smoked fish. This activity not only strengthens the tourism aspect of the site but also promotes superior products such as dried and smoked fish.

The integration of fish processing with ecotourism is a coastal development model in Lembung Village that combines marine-based economic activities with educational, sustainable, and environmentally friendly tourism experiences. Ecotourists not only purchase processed fish products but also learn about marine fish processing technology, increase the added value of fisheries products, enjoy the coastal environment sustainably, and create tourism jobs. Integration not only focuses on ecotourism but also considers aspects of a sustainable coastal environment, community empowerment, and education, where ecotourists are taught about marine conservation and the importance of sustainable fisheries.

## CONCLUSION

Coastal areas with their biodiversity, if managed seriously, can become centers of economic growth and drivers of improved community welfare. Therefore, multi-stakeholder synergy between universities, community groups, village governments, and other stakeholders is key to the successful development of ecotourism areas and their associated micro-business ventures. As an integrated area, sustainable development is required to align with the desired goals and expectations. Polinema's consistent support for community service activities needs to continue as a manifestation of higher education's participation in accelerating coastal area development through education-focused tourism development to achieve the desired results.

Knowledge of the normal hydrological patterns in the Lembung Mangrove Ecotourism area, which regulate the distribution and growth of mangrove species, has provided a basis for informed local decision-making and supports mangrove revegetation, the development of silvofishery-style mangrove crab cultivation, and fisheries through the introduction of sustainable fish drying technology. These efforts not only focus on conservation efforts but also offer a source of economic income for local coastal communities and present opportunities for future growth in Lembung Village, Galis District, Pamekasan Regency.

Community service activities by Polinema's community members have provided benefits not only in strengthening ecotourism aspects, but also in environmental education, community empowerment, and local economic development. Ecotourists who come to visit will be able to (1) understand the importance of maintaining the mangrove ecosystem, (2) learn about the silvofishery method that combines fish farming with mangrove conservation, and (3) support the local community's economy through marine fish processing businesses that produce dried and smoked fish.

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