A sustainable ecotourism conservation model based on biodiversity analysis of Tambaan Coast, Pasuruan City, East Java Province. Indonesia

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Abstract. Currently, coastal areas are facing various pressures, resulting in degradation of the areas. The pressures come not only from anthropogenic factors but also from natural factors. However, coastal areas have coastal ecosystems which can potentially be developed into marine ecotourism areas. It is necessary to formulate a model of ecotourism conservation based on biodiversity. The study was conducted at Tambaan Beach, Pasuruan City to prepare a model of ecotourism conservation based on gastropod diversity in the mangrove forest, the presence of mudskipper, Total Suspended Solid, and type of sediments. The objective of this study is to develop a model that is suitable for the development of marine ecotourism areas that can be conserved so that they can be sampled for marine ecotourism areas elsewhere. The study employed the DPSIR (Driver-Pressure-State-Impact-Responses) model to determine the process and interaction of the relationship between the coastal environment and the surrounding humans. The results indicate that the conservation management of marine ecotourism areas based on biodiversity is essential not only for the current generation but also for future generations.

I. Introduction

This study assesses the existence of biodiversity to support the capability and carrying capacity of Tambaan Beach as a marine ecotourism area. The ocean is the most important tourist spot in the world, including coastal areas that provide natural environments such as the sea, beaches and coral reefs, as well as opportunities to watch interesting species, such as fish, sea turtles, and dolphins.

Ecotourism areas are directly dependent upon the preservation of the ocean and many species living there [1]. In general, the meaning of ecotourism is outdoor recreation which has intrinsic value and economic and environmental values. To maintain the beauty of the ecotourism environment, it is necessary to protect and restore biodiversity at the level of biodiversity, the ecological functions of the ecosystem, including how to carry out ecotourism governance with other indicators [2]. Ecotourism is designed so that there is mutually beneficial feedback between tourism activities and conservation efforts.

The integration between the two must consider synergy and mutual benefit. This implies that the preservation of biodiversity can benefit the flora and fauna, and provide welfare for the local...
community [3,4]. The relationship between ecotourism and conservation needs to be tested. According to [5], ecotourism is beneficial for conservation and development; it cannot be tested carefully when the assessment is biased by including data from activities that are not designed for ecotourism. This hypothesis argues that there are anthropogenic activities that utilize ecosystems irrationally.

Ecotourism that is based on natural resources ecologically plays a role in a unique social development system by creating various social-ecological activities [6,7]. However, some people use mangrove forest ecosystems irrationally by doing illegal logging. This activity will damage the coastal area as an eco-tourism area. However, the damage that occurs immediately can be anticipated by increasing the awareness that damage to the ecosystem will harm coastal communities.

Community awareness to start rebuilding damaged coastal areas into sustainable eco-tourism areas is needed. This can be learned from locations on the Tambaan coast of Pasuruan City, which was previously damaged. Then, coastal restoration was carried out and the area is now used as a marine ecotourism area. This study assesses whether the area biodiversity supports Tambaan Coast to become a marine ecotourism area.

2. Material and methods

2.1. General descriptive

The research was conducted on Tambaan Beach, Pasuruan City, East Java Province (Fig 1). The reason why Pasuruan City was chosen for research on diversity is that the mangrove forest of this beach was damaged in the 90s and the community began to increase they are and build this area by utilizing mangrove forests as a tourism icon. The width of this area is 35,785 hectares and the population of Tambaan in 2018 was 4,110 people [8].

![Figure 1: Study Location of this research (modification mapping from East Java Government [8])]()
Based on Figure 2 above, the results of the eco-tourism suitability analysis in table 1 are based on research [9]. The conclusion drawn is that Tambaan Beach has an S2 suitability index. This means that Tambaan Beach is categorized accordingly. The research [11] showed that the condition of the mangrove ecosystem was in the healthy category. The stems, leaves, flowers and fruits are in the right shape and do not experience defects both in terms of shape and colour.

**Table 1. Results of analysis of tourism suitability index**

| Parameters               | Weight | I    | II   | III  | IV   | V    |
|--------------------------|--------|------|------|------|------|------|
| Mangrove Thickness (m)   | 0.35   | 2    | 0.7  | 2    | 0.7  | 2    | 0.7  |
| Mangrove Density (100m²)| 0.25   | 4    | 1    | 4    | 1    | 4    | 1    |
| Mangrove Types           | 0.17   | 2    | 0.34 | 2    | 0.34 | 2    | 0.34 |
| Biota                    | 0.13   | 3    | 0.39 | 3    | 0.39 | 3    | 0.39 |
| Tides                    | 0.1    | 2    | 0.2  | 2    | 0.2  | 2    | 0.2  |
| Total                    |        | 2.63 | 2.63 | 2.63 | 2.63 | 2.63 | 2.63 |
| Value of confirmity      |        | 65.8%| 63.8%| 63.8%| 63.8%| 63.8%| 63.8%|
| Confirmity category      |        | S2   | S2   | S2   | S2   | S2   |

**Figure 2.** Mangrove Tambaan Village year 2004 (A) and 2019 (B)

2.2.2. Sediment distribution and transport
Sediment transport in Tambaan waters requires a Hjulstrom curve. This curve uses data of current velocity (cm/s) and an average diameter of sediment grains (mm). Based on research [10], a graph of the Hjulstrom is presented in the Figure 3. Based on the Hjulstrom Curve above, the sediment transport in the waters of Tambaan Beach is transport in suspension. This sedimentary pattern floats and easily moves in the direction of the current and deposition of suspended load where the sediment drifts over time will be deposited following the speed of the current.
2.2.3. Gastropod community structure
The structure of the gastropod community [11] in the mangrove ecosystem on Tambaan Beach shows that the diversity index (H') is categorized medium category with a value of 1.51-1.75. Uniformity index (E) shows the high category with a value of 0.57-0.66. The dominance index (C) is low. So, there are no gastropods with a value of 0.18-0.28. The relationship between gastropod density and mangrove density in the mangrove ecosystem is high with a value of r = 0.9365. R² with a value of 0.8771 means 87% of mangrove density is able to affect gastropod density.

Table 2. Total density of gastropoda species found in Tambaan Waters

| Species                  | Station 1 | Station 2 | Station 3 | Station 4 | Station 5 |
|--------------------------|-----------|-----------|-----------|-----------|-----------|
| Canarium labiatum        | 13.2      | 12        | 12.8      | 15.8      | 13.2      |
| Turbo chrysostomus       | 7.4       | 0         | 8.6       | 9         | 14.8      |
| Cerithidea cingulata     | 29.8      | 23        | 18.8      | 28.4      | 21.8      |
| Telescopium telescopium  | 14.4      | 20.4      | 8.6       | 14.8      | 0         |
| Volegalea cochlidium     | 0         | 13.2      | 16.6      | 19.2      | 13.2      |
| Penion maximus           | 13.6      | 14.2      | 12.6      | 0         | 12.8      |
| Total                    | 78.4      | 82.8      | 78        | 77        | 75.8      |

2.2.4. Glodog fish species diversity (Family: Gobiidae) in the mangrove ecosystem
The results of research [12] indicated that mudskipper found in Tambaan beach consisted of 3 genera and 4 species. Mudskipper species include Boleophthalmus boddarti, Periophthalmus chrysospilos, Periophthalmodon schlosseri, and Boleophthalmus pectinirostris. The value of diversity (H') ranges from 1,085-1,229. The highest value of diversity is 1,229. The diversity value is 1,085. For mudskipper, the ecological index includes the value of Density, Uniformity, Diversity, and dominance. Absolute density values range from 34-54 ind/m² with the highest absolute density value of 54 ind/m² and the lowest absolute density value of 34 ind/m². The uniformity index value at the research station is in the range of 0.783-0.887. The highest uniformity index value is 0.887 and the lowest uniformity index value is 0.783. The dominance value (C) of mudskipper ranges from 0.382 -
0.326. The highest dominance value with uniformity value is 0.382 and the lowest is 0.326. The highest mudskipper population density with a value is 54 ind/m² and the lowest is 34 ind/m².

2.2.5. Total suspended solid distribution
The distribution pattern of TSS [13] in residential areas shows TSS content ranging from 247-250 mg/L. TSS content in aquaculture areas ranges from 243-246 mg/L. Meanwhile, TSS content in the area of fishponds ranges from 256-259 mg/L while for river mouths, the TSS content ranges from 268-274 mg/L. For mangrove areas, TSS ranges from 237-242 mg/L. For the port area, TSS content ranges from 176-186 mg/L. On the TSS distribution map in Tambaan Coast waters, the highest value was 274 mg/L and the lowest value was 176 mg/L.

![Figure 4. Distribution map of TSS in Tambaan Coast](image)

2.3. Methods
This study used the DPISR (Driver-Pressure-State-Impact-Response) model. The model illustrates that all human activities that affect the environment can be classified as Pressure. Special attention must be paid to anthropogenic effects on coastal areas. This pressure aspect has an impact on the use of coastal areas for marine ecotourism. Although the damage that occurred in 2004 and in 2019 has been restored by the community, biodiversity aspects are still affected. Therefore, this model addresses exogenous factors acting on the human-environment relations system.

![Figure 5. The illustrates of DPSIR model](image)
3. Results and discussion

3.1. Results

The results obtained using the DPSIR model of human-environmental systems as shown in Figure 6 show that Coastal ecosystem services are benefits provided by humans through services obtained by humans. The existing ecosystems, such as mangroves, mudskippers and gastropods, water quality, the presence of sharks and community life both from a social, economic and cultural perspective, are very suitable to be developed as a support for marine ecotourism areas. Thus, the ecosystem condition of Tambaan Beach provides services through coastal ecosystem services for the community and tourists visiting Tambaan Beach.

![DPSIR-based model of human-environmental systems](image)

**Figure 6:** DPSIR-based model of human-environmental systems [14]

3.1.1. State

The temperature in Tambaan Coast waters ranges from 29.4°C to 31.5°C, the brightness ranges from 0.12 meters to 0.24 meters, the current speed ranges from 0.011 m/s to 0.027 m/s, dissolved oxygen ranges from 5.87 mg/L to 19.25 mg/L, the pH ranges from 7.49 to 7.85 and salinity ranges from 20.20 ‰ to 25.16 ‰. The physical and chemical results of the Tambaan coastal waters are excellent for biodiversity, supporting the area as a marine ecotourism area.

3.1.2. Pressure

In general, the pressures predicted to cause changes in ecosystem services on Tambaan Coast can be classified as general pressure and special pressure. General pressure causes changes in the function of ecosystem services due to climate change in the form of an increase in sea level, including tidal flooding. On the other hand, according to the results of a study [15], plastic waste is currently scattered and reduction has been carried out through a distillation machine to convert plastic waste into fuel (diesel, premium, kerosene). Besides that, there is no processing of domestic waste, either waste liquid or solid waste. This condition, if not treated immediately, will cause pollution to coastal waters.

3.1.3. Drivers

Drivers are the main factor that causes changes in the ecosystem at Tambaan Beach. This drive factor is a combination of various factors, such as biophysical, human, and institutional. Anthropogenic
activity is the main cause of changes in coastal ecosystems such as irrational use of natural resources and water pollution due to waste disposal. In addition, environmental health is a central issue on this beach. This is because the population density is very high. For the Panggungrejo sub-district, the population density reaches 8,570 people/Km$^2$.

3.1.4. Response to Ecosystem Services
Based on the response of the Tambaan community that the current existence of ecosystem services in the form of an abundance of biodiversity, the area is considered suitable to be developed as a marine ecotourism area. However, it should be noted that population growth is increasing and the availability of biodiversity becomes threatening if it is not conserved. Therefore, the determination of the Tambaan beach area as a marine ecotourism area and a conservation area must be strictly guarded through the implementation of government regulations. Therefore, community participation should not be ignored and the Pasuruan City Government must accommodate the interests of the community. These stages start from the level of Pasuruan City area to the local level. The stakeholder collaboration is based on mutual cooperation activities and the roles of various parties based on the interests of the community, government and the private sector.

3.1.5. Response to State
The response of the Pasuruan City Government related to the development plan of Tambaan Beach as a marine ecotourism area needs to be considered by maintaining biodiversity, especially the mangrove forests. Based on research, the high density of mangroves will result in good growth of gastropods, mudskipper, fish abundance, the level of water brightness with low sedimentation. Besides that, based on research focusing on the reduction of plastic waste in the coastal area, a synergistic relationship has been established between the Karangtaruna group and the garbage bank to manage plastic waste. Synergy between community interests and government policies including the private sector is the main prerequisite for the formulation of government policies to manage the Tambaan coastal area. However, threats that will affect the use of coastal areas for various activities must be anticipated as early as possible, such as illegal logging of mangrove forests, the availability of facilities and infrastructure. For this reason, the government must firmly reject all activities that will take advantage of establishing permanent houses or business premises such as hotels.

3.1.6. Response to Pressure
The pressure response is related to threats in coastal areas related to land use change, climate change, plastic pollution, and population growth, including habitat destruction. For this reason, governments, communities and the private sector are jointly committed to addressing or adapting to environmental threats. This requires a mutual agreement between all stakeholders in the form of a Cooperation Agreement.

3.1.7. Response to Drivers
The response to movers is related to the cause of changes in the coastal ecosystem. The government, the community, and the private sector are responsible for the destruction of coastal ecosystems. In addition, changes in land use and conservation of mangrove forests are the main focus of preserving biodiversity. These factors are important agenda in the planning, implementation and utilization stages as well as evaluation and monitoring.

3.2. Discussion
A sustainable ecotourism conservation model based on biodiversity analysis using the DPSIR model shows that the new paradigm of ecotourism area planning must pay attention to biodiversity comprehensively as a basis for planning marine ecotourism areas. The argument is that sustainable ecotourism areas must be comprehensively assessed based on ecological assets. Currently the planning paradigm, utilizing marine ecotourism areas is only based on economic growth aimed at creating
employment opportunities. As stated by [16] that capital is important to alleviate poverty in coastal areas by using and exploiting ecological assets without paying attention to the aspect of sustainability. Thus, the planning and utilization of marine ecotourism areas is not only based on the physical conditions of the ecosystem such as water transparency, conditions of coral reefs, mangroves, conditions of marine life and water quality conditions, but also planning for sustainable ecotourism areas. A new paradigm needs to be used as a model for marine ecotourism areas in Indonesia in the future. Future conditions are unpredictable conditions, increased population growth, global climate change, natural disasters such as tsunamis, earthquakes, erosion and sedimentation processes are often not included as important variables in planning coastal areas. The flora and fauna habitats are threatened due to the very high pressure from the coastal areas, causing these ecological assets to be threatened and indirectly decreasing the intrinsic value of marine ecotourism areas. Therefore, the DPSIR model approach is the best alternative.

4. Conclusion
With regard to the sustainable ecotourism conservation model based on the analysis of biodiversity on Tambaan Beach, the following conclusions can be drawn: In terms of carrying capacity and land suitability, Tambaan Beach is suitable to be developed with an IKW value of 65.75% and the carrying capacity value of the Region can accommodate 42 visitors per day, with 30 visitors for tracking and 12 visitors for fishing tours. Good physical and chemical water qualities support marine ecotourism area in Tambaan coast. The intrinsic coastal landscape of Tambaan area is very suitable for a marine ecotourism area with abundant gastropods and mudskippers. The healthy coastal environment is mainly supported by the mangrove species of Rhizophora mucronata resulting from restoration carried out by the community.

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