Planning policy formulation of coastal area in Gili Ketapang Island, Probolinggo, East Java

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Abstract. Gili Ketapang is an island with many villages activity that has many different occupations such as trader, home industry, transportation services, retired workers, fishers, and any other. Gili Ketapang’s ecology condition indicates a decreasing in the quality environment. The environmental effect affects coral conditions and decreases fish abundance. The purpose of this research is to formulating policy for the Probolinggo government for mid-term years. The main target of this research is creating a map based on GIS with a zoning system to determine conservation area and non-conservation areas. The method used to achieve the purpose is PLS (Partial Least Square), AHP (Analytical Hierarchy Process), and GIS method. PLS method used to choose the priority based on the multivariate technique that can use many kind variables such as response variable to an explanatory variable with simultaneous. AHP method used to make the best decision from many alternatives includes the procedure. The ground check activity includes collecting primary and secondary data of Gili Ketapang, such as questioner and oceanography measurement (wind, currents, waves, and tidal). The result of this research produces a set of policies to monitor coastal land use of Gili island.

1. Introduction
Small islands get an impact by climate changes and consequences to ecological conditions, especially sea-level rise. The tidal flood has caused many people to live in coastal areas to suffer much. The suffering was not only material loss but also claimed lives. This requires thinking about how to save and adapt to coastal communities. Pressure on small islands and coastal areas continues to increase. This is because the population continues to increase, and natural resources on small islands are increasingly irrational.

Global climate change can damage coral reefs and affect other ecosystem conditions and further affect fisheries and food crops. It can affect subsistence, and commercial fisheries, including marine ecotourism activities, and small islands often have limited resources for freshwater supply services [1] [2].

The small islands’ condition, which is small in size, isolated and remote, makes them very prone to natural disasters. The vulnerability of environmental problems must be handled holistically and more integrative. The application of a spatial system and management of scarce and limited natural resources through a zoning system maintains the balance of highly sensitive ecosystem resources. Some say that
“win-win solution” or “small loss” is a combination of great benefits that can provide many benefits for land users and communities through coastal ecosystem services and integrated spatial planning to be able to bring together different sectors [3] [4].

The problem with Gili Ketapang Island is the increasing population growth while the availability of natural resources, carrying capacity, and the island’s ability is limited. The population growth rate on Gili Ketapang island is 1,19 % [5].

Meanwhile, the landscape and seascapes of the island of Gili Ketapang show deteriorating ecological conditions due to anthropogenic factors. This condition is due to unclear zoning of areas that need to be conserved, in cultivation, including for snorkelling ecotourism activities. If the conditions of the Gili islands are without spatial planning, the ecological damage will continue. The purpose of this research is to formulate a policy formulation for the Probolinggo Regency Government in the zoning of the Gili Ketapang coastal area and to advise the Probolinggo Regency Government to develop a strategy in the next 5 years. This research’s particular target is creating map based on GIS zoning system to choose where conservation area, residential area, marine ecotourism area, and commercial areas.

2. Method

2.1. General descriptive

The research was conducted on Gili Island in East Java Province (see Fig 1). For research, Gili Island was chosen because it requires a management model for small islands for rational use and control of space. Gili Ketapang Island has an area of 68 Ha of water. The total population of 9,617 people in 2019 consists of 4,740 men and 4,877 women.

![Figure 1. Map of Gili Ketapang Island Imagery Probolinggo, East Java](Source: Probolinggo regency, 2017).

2.2. Materials

2.2.1. Method. This research was conducted in four (4) stages. Firstly, determining area units such as landscape, geology, soil, waters, land use, flora, fauna, and land. Secondly, the first part determined the ecological structure and priority island ecosystems, while the second part determined the ecological structure and secondary island ecosystems. Thirdly, spatial data was processing using GIS. Fourth, mapping the zoning of Gili Ketapang Island used GIS.

The PLS method was a multivariate statistical technique that could handle many response variables and explanatory variables. This analysis was an excellent alternative to the methods of multiple
regression analysis and principal component regression. Model parameters did not change much when new samples were collected from the total population. The PLS results would produce a management policy for the island of Gili Ketapang that could be used as an alternative source of spatial planning. The evaluation of the sustainability management at Gili Ketapang islands combines with the results of an analysis of ecosystem conditions such as: ecological, economic, and social. Analytical Hierarchy Process (AHP) was used to formulate policies for sustainable management of mangrove forest ecosystems. Therefore, zoning planning using GIS used a policy approach to developing marine zoning structures in water areas, including increasing access to zoning services as an alternative use and control of zoning. This zoning determination uses for the benefit of the community, government, and private sector, to be able to regulate every activity on the Gili islands so as not to damage the spatial structure. Thus, the quality and range of spatial services can be identified for allowed areas and should not be allowed.

2.2.2 Data

2.2.2.1. Types and number of respondent. A survey conducted to collect people’s aspirations to determine the community’s interest in managing and utilizing the Gili island space by distributing questionnaires to the community. Table 1. Type and number of respondents show the types and number of respondents interviewed.

| No  | Types of Respondents                                      | Number of Respondents |
|-----|-----------------------------------------------------------|-----------------------|
| 1.  | Local People                                              | 15 people             |
| 2.  | Village of Apparatus                                      | 10 people             |
| 3.  | Snorkelling Community group                               | 10 people             |
| 4.  | Planning Development Board Probolinggo Regency            | 5 people              |
| 5.  | Fisheries Services of Probolinggo Regency                 | 5 people              |
| 6.  | Tourism Services Probolinggo Regency                      | 5 people              |
|     | Total of Respondents                                      | 50 people             |

2.2.2.2. Physical and chemical waters data. The physio-chemical parameter survey for waters is carried out by measuring current, wave, temperature, DO, Nitrate, Nitrite. Measurements made at 5 observation stations, which are considered to represent the location of Gili Ketapang waters. The measurement results can be seen in Table 2 below.

| Parameter     | Units | Station 1 | Station 2 | Station 3 | Station 4 | Station 5 |
|---------------|-------|-----------|-----------|-----------|-----------|-----------|
| Current       | (m/s) | 0.06      | 0.04      | 0.16      | 0.16      | 0.13      |
| Wave          | (m)   | 0.01      | 0.01      | 0.03      | 0.02      | 0.02      |
| Temperature   | (°C)  | 29.2      | 29.2      | 29.3      | 28.6      | 28.7      |
| Dissolve Oxygen| (mg/l) | 4.2       | 4.3       | 4.3       | 4.7       | 4.4       |
| Nitrat        | (mg/l) | 0.039     | 0.051     | 0.063     | 0.054     | 0.046     |
| Nitrit        | (mg/l) | 0.025     | 0.031     | 0.026     | 0.035     | 0.024     |
The results of direct sea surface temperature measurements show that the temperature of Gili Ketapang waters is relatively the same, ranging from 28.2° - 29.4° C. In general, the surface temperature of the waters is between 28° - 31° C.

Current velocity and surface wave height in Gili Ketapang strongly influenced by wind and tidal movements. Current velocity ranges from 0.04 - 0.16 m / s. This speed is different at each survey point. This is due to differences in characters at each survey point. Surface wave height has the same relative value at each survey point and tends to lower altitude. This is due to the position of Gili Ketapang Island between Madura Island and Java Island, which is not directly adjacent to the open sea/ocean. The value of the wave height is 0.01 - 0.03 m.

Dissolved oxygen survey results have a range of values between 4.2 - 4.7 mg / L. Based on the survey results, and compared with the water quality standards, then the condition of Gili Ketapang waters tends to be less useful. This is because the water quality standard for dissolved oxygen is 5 mg / L.

The value of nitrate levels in the waters of Gili Ketapang ranges from 0.039 - 0.063 mg / L. If this value is compared with the water quality standard, the nitrate content in the waters around Gili Ketapang tends to be less useful. This is because the standard of nitrate levels in the water quality standards has a value of more than 0.008 mg / L so that the Gili Ketapang waters are much higher for the value of nitrate levels.

The value of the nitrite content in Gili Ketapang waters ranges from 0.024 - 0.035 mg / L. Nitrite levels in waters greater than 0.05 mg / L can be toxic to organisms. Therefore, the nitrate content in the waters of Gili Ketapang is still within reasonable limits, so it is safe for aquatic organisms’ lives.

3. Results and discussion

3.1. Analytical Hierarchy Process

AHP was analysed based on the results of interviews with 50 respondents. The questionnaire on the community’s role is more directed at how the community’s role and attitudes towards the 13 main questions posed include how the role of society in ecological sustainability, the role of society in action, preservation of the white sand ecosystem. The perceived lack of local government attention and limitations, preservation of water quality, preservation of coral reef ecosystems.

The results of AHP (see Figure 2) analysis related to concerns as follows: shipping safety, high levels of water pollution, management of the Gili Ketapang Island area, limited development of marine tourism areas, minimal facilities and infrastructure, disproportionate allocation of APBD funds, and commitment to developing Gili Ketapang Island show that ecological sustainability is a priority for attention.

The results of the AHP analysis of Ketapang Island show that the coefficient of the highest value is the need for ecological sustainability on the Gili Ketapang Island with a variable coefficient of 0.190.
While the second order is the coefficient value of the community role variable of 0.163, and the third is the sustainability of the white sand ecosystem with a variable coefficient of 0.159. Thus, the Gili Ketapang island spatial planning policy’s formulation is directing at the three variables above.

3.2. Partial least square
The explanation of the structural model in Figure 3 below shows that the management manages the management strategy of Gili Ketapang Island carried out by Pokmaswas and Probolinggo Regency. The problem is whether these stakeholders are responsible for the management of the island of Gili Ketapang. Based on field observations, community variables are very dominant in the management of the Gili Ketapang island. Community variables are much help by community participation, management procedures, ecosystem preservation, air quality preservation, white sand ecological preservation, and ecological preservation around the Gili Ketapang island. The variables of the Gili island management strategy mentioned by land suitability, carrying capacity, and the number of facilities or infrastructure. These variables greatly influence the spatial plan of the Gili Ketapang island.

PLS analysis will test the convergent validity to determine each variable’s role so that the most significant interactions between variables can be found. Furthermore, the composite reliability test was carried out to find out any value between the strategy and the community’s role in the management of the Gili Ketapang island. Analysis of the criteria coefficient of each variable. Then the real influence of the Gili Ketapang island management model is calculated to see what influences the community on the management of the Gili Ketapang island.

![Figure 3. Structural modelling for formulating zonation policy in Gili Ketapang Island.](image)

3.3. Convergent validity
The size of the parameter coefficient for the community role variable (X1) is (original sample) 0.918, which means that there is a positive relationship between the role of society (X) or it can be interpreted that there is a strong relationship between the role of society and society. The value of t - Statistics of 32,478 Significant (t table of 5% significance = 2). Therefore, the t statistical value is smaller than t-table 2 (32.478> 2). The size of the parameter coefficient for the coastal area management variable in Gili Ketapang village (X2) is (original sample) 0.894, which means that there is a positive relationship between the role of the community (X) or it can be interpreted that there is a strong relationship between the role of the community and the community. The value of t - Statistic of 28,296 Significant (t table of 5% significance = 2). Therefore, the t statistical value is smaller than t-table 2 (28,296> 2). The size of
The parameter coefficient for the Coral Reef Ecosystem Sustainability variable (X3) is (original sample) 0.840, which means that there is a positive relationship between the role of the community (X) or it can be interpreted that there is a strong relationship between the role of the community and the community.

The coefficient of the variable parameter of the Quality of Sustainable Coastal Waters in Gili Ketapang Village (X4) is 0.858. This value means that there is a strong relationship in the role of society; the t-statistic value of 25.910 is significant (t table significance 5% = 2). Therefore, the t statistical value is smaller than t-table 2 (25,910 > 2). The magnitude of the parameter coefficient for the variable Sustainable Quality of Coastal Waters in Gili Ketapang Village (X5) is (original sample) 0.858, which means that there is a positive relationship between the role of the community (X) or it can be interpreted that there is a strong relationship between the role of the community and the community. The t-statistic is 25,910 significant (t table 5% significance = 2). Therefore, the t statistical value is smaller than t-table 2 (25,910 > 2). The parameter coefficient value for the White Sand Ecosystem Sustainability variable (X6) is 0.914. This figure means that the coastal ecosystem’s sustainability has a close relationship with the role of the community (X) with a significant t-statistic value of 32.588 (t table of 5% significance = 2). Therefore, the t statistical value is smaller than t-table 2 (32,588 > 2).

Table 3. Outer loadings (Mean, STDEV, T-Values).

|       | Original Sample (O) | Sample Mean (M) | Standard Deviation (STDEV) | T (O/STERR) | Statistics P Values |
|-------|---------------------|-----------------|-----------------------------|-------------|--------------------|
| X1    | The role of community. (X) | 0.918 | 0.912 | 0.028 | 32.478 | 0.000 |
| X2    | The role of community (X) | 0.894 | 0.891 | 0.032 | 28.296 | 0.000 |
| X3    | The role of community (X) | 0.840 | 0.837 | 0.048 | 17.580 | 0.000 |
| X4    | The role of community. (X) | 0.903 | 0.897 | 0.032 | 27.878 | 0.000 |
| X5    | The role of community. (X) | 0.858 | 0.859 | 0.033 | 25.910 | 0.000 |
| X6    | The role of community. (X) | 0.914 | 0.911 | 0.028 | 32.588 | 0.000 |
| Y1    | Gili Ketapang management(Y) | 0.948 | 0.942 | 0.034 | 27.670 | 0.000 |
| Y2    | Gili Ketapang management(Y) | 0.848 | 0.847 | 0.078 | 10.911 | 0.000 |
| Z1    | Community strategy. (Z) | 0.890 | 0.890 | 0.030 | 29.900 | 0.000 |
| Z2    | Community strategy (Z) | 0.919 | 0.918 | 0.021 | 43.640 | 0.000 |
| Z3    | Community strategy (Z) | 0.806 | 0.801 | 0.064 | 12.622 | 0.000 |
| Z4    | Community strategy (Z) | 0.864 | 0.866 | 0.043 | 20.031 | 0.000 |

3.4. Cross loading and composite reliability

Discriminant validity is the ‘loading’ for each indicator expected to be higher than the ‘cross-loading’ of each. If the Fornell-Larcker criterion assesses discriminant validity at the construct level (latent variables), then ‘cross-loading’ is possible at the indicator level. In the cross-loading between the indicator and the construct measuring variable values above 0.70. It should be dropped from the model because the indicator value should be below 0.70. However, the outer loading value of 0.5 can still be tolerated to be included in a still under development model.

The second criterion for discriminant validity is to compare the Average Variance Extracted (AVE Roots) roots for each construct with the correlation between the constructs and the other constructs in the model. The model has sufficient discriminant validity if the AVE root for each construct is greater than the other constructs’ correlation. AVE. AVE Value for Community Strategy (Z). The mean of extract variants with a value > 0.5 was used as a determinant of convergent validity. So if <0.5, then it is not convergent valid.

The value on the table below reflects the reliability of all indicators in the model. The minimum value is 0.7, while ideally, the composite reliability value for Z is 0.893 and for X is 0.947.
Table 4. Cross Loading (Mean, STDEV, T-Values).

|                | Original Sample (O) | Sample Mean (M) | Standard Deviation (STDEV) | T Statistics (O/STERR) | P Values |
|----------------|---------------------|-----------------|----------------------------|------------------------|----------|
| X1 <- The role of community (X) | 0.787 | 0.912 | 0.028 | 32.478 | 0.000 |
| X2 <- The role of community (X) | 0.913 | 0.891 | 0.032 | 28.296 | 0.000 |
| X3 <- The role of community (X) | 0.787 | 0.837 | 0.048 | 17.580 | 0.000 |
| X4 <- The role of community (X) | 0.768 | 0.897 | 0.032 | 27.878 | 0.000 |
| X5 <- The role of community (X) | 0.949 | 0.859 | 0.033 | 25.910 | 0.000 |
| X6 <- The role of community (X) | 0.947 | 0.911 | 0.028 | 32.588 | 0.000 |
| Y1 > Gili Ketapang management (Y) | 0.948 | 0.942 | 0.034 | 27.670 | 0.000 |
| Y2 > Gili Ketapang management (Y) | 0.848 | 0.847 | 0.078 | 10.911 | 0.000 |
| Z1 <- Community strategy (Z) | 0.772 | 0.890 | 0.030 | 29.900 | 0.000 |
| Z2 <- Community strategy (Z) | 0.923 | 0.918 | 0.021 | 43.640 | 0.000 |
| Z3 <- Community strategy (Z) | 0.801 | 0.801 | 0.064 | 12.622 | 0.000 |
| Z4 <- Community strategy (Z) | 0.790 | 0.866 | 0.043 | 20.031 | 0.000 |

The second criterion for discriminant validity is to compare the Average Variance Extracted (AVE Root) root for each construct with the correlation between the construct and the other constructs in the model. The model has sufficient discriminant validity if the AVE root for each construct is greater than the other constructs’ correlation. AVE value for the Community Strategy (Z) with an average variant of the extract with a value > 0.5, which is used as a determinant of convergent validity. So if <0.5, then it is not convergent valid as seen in Table 5.

Table 5. AVE.

|                | AVE |
|----------------|-----|
| Community strategy (Z) | 0.679 |
| The role of Community (X) | 0.743 |

This value reflects the reliability of all indicators in the model. The minimum value is 0.7, while the composite reliability value for Z is 0.893 and for X is 0.947, as seen in Table 6.

Table 6. Composite Reliability.

|                | AVE |
|----------------|-----|
| Community strategy (Z) | 0.893 |
| The role of Community (X) | 0.947 |

3.5. Path coefficients

The size of the parameter coefficient for the community role variable (X) is (original sample) 0.854, which means that there is a positive influence between the role of the community (X) on the management of Gili Ketapang (Y). Alternatively, it can be interpreted that the better the community’s role, the better the management strategy of Gili Ketapang will be. The t value - The statistic of 25.880 is significant (t table of 5% significance = 2). Therefore, the t statistical value is smaller than t-table 2 (25,880 > 2).

The size of the parameter coefficient for the community role variable (X) is (original sample) 0.729, which means that there is a positive influence between the role of the community (X) on the management of Gili Ketapang (Y). Alternatively, it can be interpreted that the better the role of the community, the
better the management of Gili Ketapang will be. The value of t - The statistic is 19.753 SIGNIFICANT (t table 5% significance = 2). Therefore, the t statistical value is smaller than t-table 2 (13.937> 2).

3.6. Gili Ketapang zoning
Gili Ketapang is one of the small islands in East Java Province. Administratively, this island belongs to the Probolinggo Regency area. Gili Ketapang Island has unique coastal and small island ecosystems group into 4 zones, namely the core zone, sustainable fisheries zone, utilization zone, and other zones.

The core zone is part of a conservation area in coastal areas and protected small islands, which is handled to protect the habitat and population of coastal resources and small islands, and its use is limited for research. A sustainable fishery zone is a part of a marine conservation area whose location, condition, and potential can support the interests of conserving the core zone and the use zone. The utilization zone is a part of a water conservation area where the location, condition, and natural potential are prioritized for the benefit of marine tourism and the environment and research and education activities. The other zone is used for rehabilitation activities.

![Zoning Map of Gili Ketapang, Probolinggo, Jawa Timur](image)

**Figure 4.** Gili Ketapang zoning.

Besides having four zones, Gili Ketapang Island also has five sub-zones, which are derivatives of the central zone. The five sub-zones are the core sub-zone, tourism sub-zone, aquaculture sub-zone, capture fisheries sub-zone, and rehabilitation sub-zone. The total area of the zone and sub-zone reaches 476.78 Ha where the core zone has an area of 15.16 ha, the utilization zone (tourism sub-zone) is 25.63 Ha, the sustainable fisheries zone is 421.93 Ha, which divided into 23.50 Ha for aquaculture sub-zone, and 398.43 for capture fisheries sub zone and other zones (rehabilitation sub-zone) has an area of 14.06 ha. To be more precise, see the chart below.
4. Conclusion
Increasing the community’s role and the management strategy of Gili Ketapang will improve the governance of Gili Ketapang. A significant t-value indicates this. Gili Ketapang Island has unique coastal and small island ecosystems grouped into four zones, namely the core zone, sustainable fisheries zone, utilization zone, and other zones. Each zone has its purpose and function. Future research in Gili Ketapang should hold a group discussion with the local government to advise small island management and insert some of the technical issues on the RPJMD of Probolinggo.

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