Sustainability Analysis of Coastal Eco-tourism Management of Bawean Island, East Java

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Abstract: Bawean island is a small island located around 80 miles north of Gresik, East Java Province. In recent years, the island is famous as a new destination of marine and coastal eco-tourism. Sustainable eco-tourism management in a small island is a very important concept not only for increasing income of local people but also protecting the island itself from environmental degradation due to natural and anthropogenic factors. This research is intended to study the marine environment of Bawean Island; secondly, to analyze the suitability of the island and finally to formulate strategies towards sustainable management of Bawean Island as a coastal eco-tourism destination. Based on the evaluation, Bawean Island is highly recommended for coastal eco-tourism development. However, limitation on the number of visitors should be taken into account to prevent ecological disturbances. Three main approaches namely ecological, economic and social-cultural aspects should be taken into account to ensure the sustainability of coastal ecotourism in Bawean Island.

1   INTRODUCTION

Your Marine-based tourism/marine-ecotourism is defined as travel to relatively undisturbed marine and coastal areas with the specific objective of admiring, studying and enjoying the scenery. Other common activities that can be done in relation to marine-ecotourism including marine-based activities such as diving, snorkelling, fishing and many others (Farrel and Marion, 2001). The common landscapes offered by marine eco-tourism destination are sandy beaches, pristine coral reef ecosystem or unique marine species (Romadhon, et.al, 2014; Pamungkas, et.al, 2014). Marine-ecotourism may provide specific opportunities for learning and discovery, and in some definitions, includes social and environmental ethics. Furthermore, well-managed ecotourism provides revenue for coastal communities and jobs for local residents. The government of Indonesia has prioritized marine-based tourism as one of the leading sectors in national maritime development. Therefore, discovery and assessment of new and potential small islands as a tourist destination are needed.

According to the Ministry of Marine and Fisheries (2014), the small island is an island with an area smaller or equal to 2,000 km2 along with the unity of its ecosystem. On a small island with its limited resources, social and economic activities tend to be concentrated on the coastal zone (Twining-Ward and Butler, 2002). Furthermore, interconnectivity between economic, environmental, social and cultural is strong and extensive When uncontrolled tourism development occurs in small island destinations with limited environmental carrying capacity, environmental degradation is most likely to happen (Charlie, 2014). Thereby reducing destination attractiveness (Weaver, 2005; Williams and Ponsford, 2015). This pattern is particularly prevalent in small island destinations in developing countries, where local government capacity is often lacking, resident populations have limited education and environmental awareness is poor (Apostolopoulos and Gayle, 2001). In such conditions, effective environmental conservation and sustainable management strategies are likely to be initiated and it requires collaboration between relevant stakeholders.

Sustainable island management is a very important approach not only for increasing income from tourism but also protecting the island itself from environmental degradation due to natural and anthropogenic factors (Hidayah, et.al, 2016). Eco-tourism is related to small-scale tourism where the number of tourist and type of activities is limited. On

the contrary, mass tourism development in the small island has been avoided in many counties. There a are a lot of evidence show that the practice of mass tourism development in small islands has sacrificed environmental stability and disrupted the natural pace of island life (Briguglio, 2003). The placement of large-scale beach resorts, marinas, and infrastructure along delicate coastlines has altered shorelines and depleted endemic species and archeological artefacts. Moreover, sand mining dredging and cruise ship and yacht anchoring can damage coral reefs ecosystems. Therefore, in order to develop marine tourism in a small island, it is imperative not only to study the potential natural attraction but also the island's carrying capacity and sustainability.

Bawean Island is located approximately 80 nautical miles north from the city of Gresik, East Java province. The total area of the island is around 196,27 km2 with a population according to the 2015 census was approximately 70.000 people. Compare to the mainland of East Java, this island is relatively unknown for its ecology and economic potential. Objectives of this research are firstly, to study the marine environment of Bawean Island; secondly, to analyze the suitability of the island and finally to formulate strategies towards sustainable management of Bawean Island as a coastal eco-tourism destination.

2 MATERIAL AND METHOD

This research was conducted in Bawean Island from June to August 2018. A combination of spatial data analysis using remote sensing, Geographic Information Systems (GIS) and an extensive field survey was applied in this study. A moderate resolution satellite image ALOS-AVNIR was used to map land cover and characteristic of the bottom substrate of the island. Moreover, field data collection was conducted using the standard method of ecological survey, such as coastal vegetation identification by quadratic transects, coral reefs and benthic organism observation by LIT (Line Intercept Transect), coral fish census, types of bottom substrates, depth and other important data.

Radiometric and atmospheric corrections were done to eliminate optical distortions due to atmospheric factors, sensor damage, direction and intensity of sunlight. Radiometric correction is done to enhance visual quality and remove pixel values that are not in accordance with the reflection value or spectral emission of the actual object (Hidayah and Wiyanto, 2017). Furthermore, the geometric

correction was done to transform remote sensing image, hence the image has the properties of maps in shape, scale, and projection. The most basic geometric transformation is the re-positioning of the pixel in such a way that the transformed digital image can have a similar position to recorded objects on the surface of the earth.

A standard supervised classification method using maximum likelihood algorithm was applied to group pixels with similar value into several classes. Satellite image classification plays a major role in extracting and interpretation of valuable information from satellite images (Abburu and Golla, 2015). Bands (wavelength channel) used in this study were band 1 and band 2 of ALOS-AVNIR image, which are in the blue wavelength range (0.45 to 0.52 m) and the green wavelength (0.52 to 0.60 m). These spectrums were used due to their ability to penetrate the water column to a depth of 20 meters in clear shallow water. To determine the type of substrate, Lyzenga algorithm was applied. The basic equation of this algorithm is as follow:

$$Y = \ln(Li) - \left[\left(\frac{ki}{kj}\right)\right] x \ln(Lj) \qquad (1)$$

$$\frac{ki}{kj} = a + \sqrt{a^2 + 1} \qquad (2)$$

$$a = \frac{(\sigma ii - \sigma jj)}{(2\sigma ij)} \qquad (3)$$

Li : reflectance value band 1 (blue)
σ ii : variance band 1
Lj : reflectance value band 2 (green)
σ ii : variance band 2
ki/kj : attenuation ratio band 1 and 2
σ ij : covariance band 1 and 2

Satellite image analysis can only measure the area of bottom substrates, therefore an underwater field survey is needed to be done to obtain more information regarding the coverage of each substrate types. Line-intercept transect (LIT) is one of the most common transect method, which measures the length of corals which intercept a transect line and assess the percent cover of the corals by their relative lengths (Nakajima, et.al, 2010). Results of the observation can be classified as follows (Hidayah, 2013): poor condition (living coral cover 0 to 24,9%), moderate (25-49,9%), good condition (50-74,9%) and excellent condition (75-100%).

To quantify the potential of Bawean Island as a coastal eco-tourism destination, suitability analysis was performed using a coastal tourism suitability matrix (Yulianda, 2007). This matrix consists of several parameters with certain scores and weighting.

The results of the field survey were then compared with the values in the matrix to obtain the status of suitability.

Table 1: Suitability Matrix for Beach Recreation (Maximum Score x Weighting =54).

Parameters	Weighting	Score			
		S1 (score = 3)	S2 (score = 2)	S3 (score = 1)	N (score = 0)
Water depth (m)	3	0-3	>3-6	>6-10	>10
Beach type	3	White Sand	White sand with rubble	Black sand with rubble	Muddy, steep, rocky
Beach widht (m)	3	> 15	10-15	3-<10	< 3
Bottom substrates	2	Sand	Coral with sand	Muddy Sand	Mud
Current speed (cm/s)	2	0-0.17	>0.17-0.34	>0.34-0.51	>0.51
Beach slope (o)	2	<10	>25-100	>25-45	>45
Water brightness (%)	1	>100	>85-100	50-85	<50
Beach land cover	1	Open, coconut trees	Low shrub	High shrub	Mangrove, settlement
Dangerous biota	1	None	Sea urchin	Sea urchin, lionfish	Sea urchin, lionfish, shark
Fresh water availability	1	<0.5	0.5-1	>1-2	>2

Table 2: Suitability Matrix for Snorkeling (Maximum Score x Weighting = 36).

Parameters	Weighting	Score			
		S1 (score = 3)	S2 (score = 2)	S3 (score = 1)	N (score = 0)
Coral coverage (%)	3	>75	>50-75	25-50	<25
Number of coral lifeform	2	>12	>7-12	4-7	<4
Number of coral fish species	2	>50	30-50	10-<30	<10
Water brigthness	2	> 80	50-80	< 50	< 30
Current speed (m/s)	2	0-15	>15-30	>30-50	>50
Coral reefs depht (m)	1	1-3	>3-6	>6-10	>10

Table 3: Suitability Matrix for Diving (Maximum Score x Weighting = 39).

Parameters	Weighting	Score			
		S1 (score = 3)	S2 (score = 2)	S3 (score = 1)	N (score = 0)
Water brightness (%)	3	>80	60-80	30-60	<30
Coral coverage (%)	3	>75	50-75	25-50	<25
Number of coral lifeform	2	>12	7-12	4-7	<4
Number of coral fish species	2	>100	50-100	20-<50	<20
Current speed (m/s)	2	0-15	>15-30	>30-50	<50
Coral reefs depht (m)	1	6-15	3-6	>20-30	>30

Suitability Index (SI) level of each coastal eco-tourism activities are divided into 4 different classes, namely very suitable (S1), moderately suitable (S2), less suitable (S3) and not suitable (S4). Suitability values for each category are obtained by multiplying score and weighting then divided with maximum value, the equation as follow :

$$SI = \sum \left[\frac{Ni}{Nmax} \right] x \ 100\% \qquad (4)$$

Ni: Value of each parameter (score x weighting)
Nmax: the maximum value of each category

Table 4: Category of Suitability Index (SI) for Coastal Eco-Tourism Activities (Yulianda, 2007).

No	Classification	SI Value (%)
1	Very suitable	80-100
2	Moderately suitable	50-<80
3	Less suitable	17-<50
4	Not suitable	<17

Finally, to formulate strategies towards sustainable management strategies for coastal eco-tourism in Bawean Island AHP methods was applied. Problems that can be approached using AHP methods include those relating to planning, prioritizing and alternative policies, resource allocation and solving conflict problems. The priority is obtained based on pairs of assessments using valuation or measurement ratios using certain scales. Furthermore, ratio scales which are then synthesized through their structure are

used to choose the best alternative. The advantage of the AHP method in decision making is its ability to solve complex and unstructured problems. The proposed sustainable strategy for coastal eco-tourism management of Bawean Island was analyzed through 5 levels of hierarchy, namely the main goal of optimization (level I), optimization component (level II), optimization component criteria (level III), and management priority (level IV).
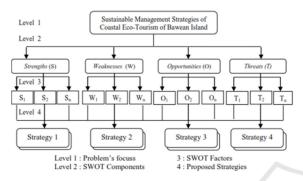

Figure 1: AHP Structure to Formulate Sustainable Management Strategies of Coastal Eco-Tourism of Bawean Island.

3 RESULTS AND DISCUSSION

3.1 Biophysical Condition of Bawean Island

The climate of the island is tropical, rainy season mostly begins from October to April while dry season starts from May to September. The average temperature of the island was 27-29oC, humidity was quite high around 70-75% and wind speed fluctuated depends on the season with a monthly average approximately 26-28 knot. Oceanographic data collection showed that the island has a diurnal tide type. Monthly average wave height was 0.5-1.5 meters depends on the season as well as current speed and direction. Measurements of bathymetry or depth profile of the island were carried out using Furuno echo-sounder equipped with GPS. The results indicated that the depth profile of Bawean Island tends to be shallow waters with a sandy substrate. The depth of shallow water ranges from 0.7 - 3.5 meters, with a slope of more than 10 meters in depth.

The extensive terrestrial and underwater survey supported by satellite image analysis was conducted to obtain complete information regarding coastal environment condition of the island. According to the survey, Bawean island has all three important ecosystems in the coastal region, namely: mangroves,

coral reefs, and seagrass. The area of those ecosystems was mapped and measured using satellite image analysis, the results are presented in Figure 2.
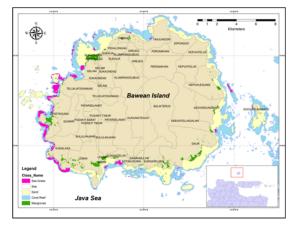

Figure 2: Results of ALOS-AVNIR Satellite Image Analysis.

The map showed that Bawean Island was surrounded by shallow water dominated by sandy substrates, followed by coral reefs and significant area of seagrass on the west side of the island. Further calculation explained that the total area of sandy substrates was around 2791,70 km2, while the calculated coral reefs area was 48,89 km2 and 3,51 km2 area of seagrass. Furthermore, satellite image analysis for the terrestrial area was successfully identified mangroves ecosystems which mostly located on the south side of the island. The total area of mangroves on the island was 17.82 km^2, dominated by Rhizophora and Sonneratia species.

Table 5: Location and Results of Underwater Survey.

No	Coordinate	% Living Coral Coverage	Status
1	05°44'33.60"S; 112°37'32.51"E	40,89	Moderate
2	05°50'23.44"S; 112°34'33.58"E	55,42	Good
3	05°44'11.22"S; 112°36'23.51"E	57,31	Good
4	05°47'59.63"S; 112°36'06.91"E	52,21	Good

To obtain information about coral coverage, the underwater survey was conducted at 5-meter depth in four locations (Table 5). According to the results, coral reef ecosystems of Bawean Island can be categorized under moderate and good condition. Living coral coverage was above 40% with mortality

index was less than 20%. These findings mean that the coral reef ecosystem in Bawean Island was relatively undisturbed by natural causes but threatened by destructive fishing operations. Based on information from the local people, in the last 10 years, the frequencies of destructive fishing activities such as blasting and using cyanide to capture ornamental coral fish were decline significantly. It was caused by intensive socialization from the government on the importance of coral reefs ecosystem to support fisheries production and a strong effort of law enforcement for those who violated the regulations.

3.2 Suitability Analysis for Coastal Eco-tourism

The assessment of suitability for potential coastal eco-tourism in Bawean Island was conducted by considering the limiting environmental parameters consisting of water brightness, living coral coverage, lifeform type, coral fish species, current speed, water depth, and several other parameters. All limiting parameters were given weights and scores based on the importance level for certain activities.

Table 6: Suitability Analysis for Beach Recreation.

Parameter	Weighting	Field Survey	Score	Weight x Score
Water depth (m)	3	0-3	3	9
Beach type	3	White Sandy	3	9
Beach widht (m)	3	10-15	2	6
Bottom substrates	2	Sand	3	6
Current speed (cm/s)	2	0,2	3	6
Beach slope (o)	2	15	3	6
Water brightness (%)	1	80	2	2
Beach land cover	1	Open, coconut trees	3	3
Dangerous biota	1	None	3	3
Fresh water availability (km)	1	0,5	3	3
Total Weight x Score :				52
Suitability values (%) :				96,29
Status :				Very Suitable

Table 7: Suitability Analysis for Snorkeling.

Parameter	Weighting	Field Survey	Score	Weight x Score
Coral coverage (%)	3	51,45	3	9
Number of coral lifeform	2	15	3	6
Number of coral fish species	2	51	2	4
Water brightness	2	> 80	3	6
Current speed (m/s)	2	0,2	3	6
Coral reefs depht (m)	1	5-15	2	2
Total Weight x Score :				33
Suitability values (%) :				91,67
Status :				Very Suitable

Table 8: Suitability Analysis for Diving.

Parameter	Weighting	Field Survey	Score	Weight x Score
Water brightness (%)	3	> 80	3	9
Coral coverage (%)	3	51,45	2	6
Number of coral lifeform	2	10	2	4
Number of coral fish species	2	35	1	2
Current speed (m/s)	2	0,2	3	6
Coral reefs depht (m)	1	5-15	3	3
Total Weight x Score				30
Suitability values (%)				76,92
Status				Moderately Suitable

Results of the analysis showed that Bawean Island was suitable as a location for various marine-based activities; for example beach recreation, diving, and snorkeling. Comparison between the results of field survey and satellite data analysis against the assigned value showed that most of the parameters were under high scores categories. Therefore the suitability values were quite high around 76-96% for each category. Based on the above's evaluation, Bawean Island is highly recommended for coastal eco-tourism development. However, limitation on the number of visitors should be taken into account to prevent ecological disturbances. Development should be

conducted in an appropriate manner with respect to minimizing development impact. Regarding the recommendation, physical structures such as green hotels, lodge, restaurants, and public convenience facilities are needed to support ecotourism on the island (Dwyer, 2018).

3.3 Formulating Sustainable Eco-tourism Management

AHP analysis showed that the sustainable management of eco-tourism in Bawean Island should prioritize coastal environmental aspects through conservation and rehabilitation. Management of eco-tourism in a small island with priority in environmental aspects is expected to create improvement of the population's economy (Miller, et.al, 2017). Therefore, the second priority was economic aspects by adding a number of jobs provided for local people, increasing income for households and creating locally owned small and medium scale business through community empowerment. The next priorities were social and cultural aspects which support the development of eco-tourism. Eco-tourism should be designed to engage local tradition as one of the main attraction, for that reason legal and capable social institution for example NGO's were also important as mutual partners for the government to actively participate in the development of eco-tourism.

Table 9: Management's Priority for Sustainable Eco-Tourism of Bawean Island.

Criteria	AHP Weighting	Priority
Environment	0,6154	1
Economic	0,1925	2
Social	0,0921	3
Conservation	0,4763	1
Ecosystem rehabilitation	0,1391	2
Increasing local revenue	0,1023	1
Creating new jobs	0,0417	2
Community empowerment	0,0485	3
Traditional culture preservation	0,0715	1
Legal and capable social institution	0,0206	2

Stakeholders priority assessment greatly determines the formulation of eco-tourism management and policies. It is important to notice that the lack of cooperation and awareness towards important issues between key stakeholders could create an unnecessary conflict of interest. The government can also create a partnership with private parties and international NGO's. In this case, partnership means to provide the government with technical assistance and advice to formulate policies on how to establish sustainable and locally based eco-tourism. In addition, the role of private sectors and NGO's can also be concentrated to improve the quality of human resources through adequate training in the aspect of entrepreneurial for the development of eco-tourism (Burgoyne, et.al, 2017).

Priority of sustainable coastal eco-tourism strategies in Bawean Island was also divided into three aspects. The first recommended strategies in environmental aspect were creating zonation of eco-tourism area. Zonation is not only dividing areas regarding its function but also an effort to plan and control tourist activities in a certain area in order to provide protection to the environment and sustainability of the coastal and small island area. Moreover, the development of the proper tourist area should base on the suitability of the existing area. Management of the area's carrying capacity was the next priority. Controlling a number of visitors in a certain time was strongly advised to protect vulnerable ecosystem such as coral reef from damages caused by ignorant and less educated visitors. It is important to notice that cautious attention to the limited resources in a small island combining with social responsibility towards the host society and culture that are influenced by recreational activities are among important factors in terms of creating sustainable eco-tourism (Asadzadeh and Mousavi, 2017). Waste management was also important to address. Improving coastal communities responsibility regarding waste handling and management was important to reduce the impact of tourism on the environment. Overall, when tourism is managed in an appropriate way, the advantages of economic and non-economic benefits, for instance, the preservation of culture and the maintenance environmental quality will be provided within (Asadzadeh and Mousavi, 2017; Zahedi, 2009).

Furthermore, to gain better economic benefits coastal eco-tourism in Bawean should be promoted in many ways, particularly via online promotion. With the rapid growth of social media users and the availability of internet connection on the island, on-line promotion should not be a major obstacle Construction of infrastructure to support eco-tourism was also an important strategy. It is important to note

that all kind of infrastructure development on Bawean Island should be studied carefully using principles of environmental impact assessment to avoid disturbance to the environment. In addition, providing creative and resilient human resources was also an important component to create sustainable and beneficial eco-tourism in Bawean Island. A series of intensive training or courses should be provided to deliver ideas in creating products, attraction or services for tourists who visit the island.

Conservation and environmental education are strategies that can directly attract tourists and the public to participate in protecting and maintaining the sustainability of coastal resources. Education in environmental conservation should be given as early as possible, for example in elementary school. By providing constant knowledge and examples of how important conservation for the sustainability of natural resources, people of Bawean Island could have self-initiative and cooperate to protect the island from damaging activities. Lastly, the development of coastal eco-tourism in Bawen Island should consider the existence of local traditions. Influence of non-traditional habits that consider inappropriate by local people should be avoided. Tourists who visit Bawean Island should be given adequate information about local customs and traditions, so they can make necessary adjustments.

4 CONCLUSION

In conclusion, Bawean Island of East Java Province is potential to be developed as a tourist destination area. It was supported by the fine condition of coral reefs and the white sandy beaches surrounding the island. The results of the analysis for potential coastal eco-tourism in Bawean Island showed that the island has quite high suitability values (76-96%) for 3 eco-tourism activities namely beach recreation, diving and snorkeling. AHP analysis showed that the sustainable management of eco-tourism in Bawean Island can be managed through the protection of coastal natural resources, providing economical-based income and education on environmental conservation.

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