Analysis of Water Environment Support for Marine Ecotourism Suitability Category Diving in Ataúro Island

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Abstract. Ataúro Island is one of the islands in Timor-Leste which has a fairly complete coastal and marine ecosystem, (coral reefs, seagrass and a few mangrove). Ataúro Island also has several long white sandy beaches where green sea turtle and Hawksbill Sea turtle are often found laying eggs in certain seasons. Coral reefs on Ataúro Island attract tourists to visit. This study aims to determine the suitability of the environmental carrying capacity of the diving category based on diving marine ecotourism suitability index. Data collection was carried out from September to November. The method used in this study is the intercept photo transects method, and water quality sampling. The results of the analysis of water quality on the island of Ataúro based on the Decree of the Minister of Environment 51 of 2004 concerning that sea water quality standards for marine ecotourism, it can be concluded that the average water quality on the island meets the quality standards. Live coral cover in all study sites had a cover of 54.80% in the 'good' category, analysis of the diving marine ecotourism suitability index for the diving category in Beloi village 75.93% in the appropriate category, Vila-Maumeta village 66.67% suitable, Biqueli 61.11% suitable.

1 Introduction

Timor-Leste has a diverse marine ecotourism potential and has a fairly high biodiversity, has own potential for ecotourism attraction. One of the areas that has considerable potential for ecotourism attraction in Timor-Leste is Ataúro Island, which is located in Ataúro Island, Dili Municipality, Timor-Leste, about 45 km from the city of Dili. Ataúro Island as a small island has a fairly complete coastal and marine ecosystem, namely coral reefs, seagrass beds and mangrove forests (mangroves). Seagrass on Ataúro Island are quite extensive and people often encounter dugongs (Dugong dugon) around waters that have seagrass beds. Ataúro Island also has several long white sandy beaches where green turtles and hawksbill turtles are often found laying eggs in certain seasons. While the waters of Ataúro are part of the

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crossing of cetaceans (whales and dolphins). On the other hand, there are several threats such as destructive fishing, garbage, sedimentation and development in coastal areas. The existence of these potentials and threats provides opportunities and challenges for better management of marine resources with active community involvement and government support demonstrating a combination of top-down and bottom-up approaches [1].

Ecotourism objects on Ataúro Island must of course be developed because tourism development in a tourist destination, both locally and regionally or nationally in a country, is closely related to the progress of development in the area. The development of tourism in an area will provide many benefits for the people living around the area, namely economically, socially and culturally. However, if the development is not prepared and managed optimally, it will cause various problems that will make it difficult or even detrimental to the people in the area. The development of a tourist area cannot be separated from the efforts made through the cooperation of tourism stakeholders, the community and the government.

The development of marine ecotourism requires determining the carrying capacity of the area so that ecotourism activities carried out can take place continuously and formulate appropriate and effective management to increase the potential of the Ataúro Island for the surrounding community. The purpose of this research is to determine the carrying capacity of the ecotourism based on diving marine ecotourism suitability index and to formulate appropriate and effective management to increase the potential of the Ataúro Island for the surrounding community.

2 Research Method

This research was conducted from September to November 2020 in Ataúro Island, Dili Municipality, with 3 different site of village that consist of Beloi, Vila-Maumeta and Biqueli, these three sites of village was chosen based on the various activity such as snorkelling, diving at the time the research took place. This research is a descriptive study using primary data and secondary data. The purposive sampling method selected primary data for water quality data collection and coral reef transects in Ataúro Island. The method of data collection and data analysis is carried out directly by using several methods as below:

Coral reef data collection was carried out using the Underwater Photo Transect (UPT) method based on [2], line transects were stretched along 50 m parallel to the coastline at a depth of 6 to 15 m, then placed a square transect measuring 1 x 1m above the coral colonies passed by the meter from point 0 (zero) at 5 m intervals. Coral cover observations were made based on the classification of coral reef lifeforms. Coral reef data analysis using Coral Point Count Excel® (CPCe) software to obtain data on coral species, coral cover, and others [3]. The category of coral reef conditions is based on the percentage of live coral cover [4].

Table 1. Percentage of Live Coral Cover [4]

Live Coral (%)	Assessment criteria
75-100	Verry Good
50-74,9	Good
25-49,9	Passably
0-24,9	Bad

Water quality data collection includes physical and chemical parameters. Where the physical parameters include water depth, water brightness, current speed, water temperature. Chemical parameters include water pH and salinity. Analysis of water quality data based on water quality standards for biota and ecotourism which refers to the Quality Standards for Marine Tourism (Kepmen LH 51 of 2004). In determining the suitability of tourism, several parameters have been determined with the criteria by [5]. The matrix is used as a reference

for using the ecotourism suitability index in determining the suitability of a location in determining tourist areas.

$$ESI\ (\%) = \sum_{i=o}^{n} \frac{Ni}{Ni\ max}\ x\ 100 \quad (1)$$

Where: ESI as Ecotourism Suitability Index (%); Ni as Parameter Value (quantity x score); Nmax as Maximum value of an ecotourism category; Ni as Parameter suitability n: Number of parameter types

Table 2. Matrix ecotourism suitability index for diving category [5]

No	Parameter	Q	S1	S	S2	S	S3	S	N	S
1	Brightness (%)	5	>80	3	50-80	2	20-50	2	<20	0
2	Coral Reef Cover (%)	5	>75	3	>50-75	2	25-50	2	<25	0
3	Lifeform	3	>12	3	>7-12	2	4-7	2	<4	0
4	Types of Coral Fish	3	>100	3	50-100	2	20≤50	2	<20	0
5	Curent	1	0-15	3	>15-30	2	>30-50	2	>50	0
6	Coral Reef Depth	1	6-15	3	>15-20	2	>20-30	2	>30<3	0

Notes:
Q : Quality
S : Score
Maximum Value : 54
Category Suitable : 25-100%
Conditionally Fit : 50- <75%
Not Suitable : < 50%

The carrying capacity to support area ecotourist attraction is one of the things that is considered in the development of an ecotourism attraction. The formula for calculating the carrying capacity of the area refers to the formula of [5], namely:

$$DDK = \frac{K\ x\ Lp}{Lt} x \frac{Wt}{Wp} \quad (2)$$

Remarks: DDK = Area Carrying Capacity; K = Ecological potential of visitors per unit area; Lp = Total area/length of area that can be utilized; Lt = Unit area for certain categories; Wt = Time provided by the area for ecotourism activities in days; WP = Time spent by visitors for each specific event.

Table 3. Carrying Capacity based on Activities

No	Activity	K	Lt (m2)	Wp (s)	Wt (Person/Day)	Remarks
1	Diving	2	2000	2	8	2 person in 200m x 10 m
2	Snorkeling	1	500	3	6	1 person in 100 m x 5 m
3	Lamun	1	250	2	8	2 person in 50 m x 5 m

Observation of reef fish using direct counting method (underwater visual census) on the same line transect for laying a quadratic transect on observation of coral biota, namely a line transects stretched along 50 m parallel to the line the coast, the type of fish that is counted is only limited by the length of the transect that has been stretched previously on coral data collection using the visual method which was 2.5 m above sea level the left, right, and top of the stretched transect position [6].

Data analysis of reef fish was performed using the Shannon-Wiener diversity (H'), evenness (E), and dominance indices (C). Biota diversity is calculated based on the Shannon Wiener [7] formula; see Equation below

$$H' = -\sum_{i=1}^{S}(Pi \ln Pi) \quad (3)$$

$$Pi = \frac{ni}{N} \quad (4)$$

Where H' is Shannon-Wiener diversity index, n_i is species number, and N is total species.

The Evenness index (E) or species distribution index shows the distribution pattern of a species in a community. If the distribution index is high, it indicates that the species is evenly distributed [8]; the evenness value can be calculated as follow (Equation 5 and 6):

$$E = \frac{H'}{HMax} \quad (5)$$

$$HMax = Ln\ S \quad (6)$$

Where E is evenness value; H': diversity index; Hmax: Diversity index maximum; S: total species.

To see the dominance of a species, the dominance index according to [7] using the following equation:

$$C = \sum_{i=1}^{S}(Pi)(Pi) \quad (7)$$

where C is index dominance; Pi = proportion of the species to the total amount of biota cover.

3 Results and Discussion

The results of observations of water quality at each data collection station in this research show that the power of hydrogen (pH) have the same result which is 7 at all village, the average of salinity between 24-25 ppt, the temperature in Beloi Village is low than other village but, in this research, temperature is still in a good condition that can be tolerated by coral reefs. Coral reefs can tolerate a range of temperatures 25-32°C to survive [9], the temperature form Beloi Village and Biqueli Village have the range of temperature 21-24°C where it's classified lowed, this is due to the time the temperature measurement was carried out on a sunny morning and at a depth ranging from 6.3-6.9 m. Temperature exceeds the limit tolerance of coral reefs can cause coral bleaching.

Table 4. Water Quality Observation Results

Parameter	Research result/Village			Water Quality Standards for marine ecotourism (Kepmen LH 51, 2004)
	Beloi	Vila-Maumeta	Biqueli	
pH	7	7	7	7-8.5
Salinity (ppt)	25	24-25	24-25	Alami3
Temp (°C)	21	27	24	Alami3
Brightness (m)	6	6-6,2	6	>6
Depth (m)	6,5-6,8	6-6,6	6,3-6,9	-
Current (cm/s)	33,3-34,4	30,4-34,2	32,6-35,6	-
Substrat	RS	RS	RS	-

Notes: Rocky Sand

pH at all stations is in the neutral range of 7. Referring to the Minister of Environment Decree No. 51 of 2004, the best pH of seawater for marine biota, including coral reefs, is between 7-8.5. In general, the pH of seawater does not very much, because the carbon dioxide system in seawater has a strong buffering capacity. This means that the pH of seawater is not easy to change [10]. Salinity in Beloi Village 25‰, in Vila and Biqueli between 24-25‰. Referring to the Minister of Environment Decree No. 51 of 2004, the water quality standard for coral growth is 33-34‰ but the salinity in these three villages is classified as salinity that is not good for coral reef growth. The optimum salinity for coral to survive ranges from 30-35‰ [11]. The current velocity at each station is different, at the time of data collection the strongest current is at the Desa Beloi station with an average value of 33.57 cm/s or 0.34 m/s and the weakest current is at the Desa Vila station with an average value of 32.30 cm/s. s or 0.32 m/s. Current velocity has a very high relationship, maybe this is because the current will carry the oxygen needed by coral reefs and other biota and the strength of the current affects the amount of food carried and affects the growth rate of coral animals [12] [13], the current maximum speed of marine ecotourism in the diving category is 0-17 cm / sec. If we refer to the standard for seawater needs for marine ecotourism based on Attachment II to Decree of the Minister of Environment 51 of 2004, it can be concluded that the water quality at each location is suitable for marine ecotourism.

Table 5. Percentage of coral reef

Village	Cover (%)				Average	Category
	St. 1	St. 2	St. 3	St. 4		
Biqueli	35.45	54.85	33.64	36.17	40.03	Moderated
Beloi	62.12	58.05	96.97	79.70	74.21	Good
Vila	23.03	56.67	64.55	56.36	50.15	Good
					54.80	Good

The coverage of coral reef conditions at each station was carried out at a depth of 6 meters. The percentage of coral reef cover shows the value of the condition of coral reefs living, coral reefs that can be categorized as live coral reefs are Acropora, Non-Acropora and Soft Coral. The condition of coral reef cover on Ataúro Island generally has good criteria with an average percentage of coral reef cover of 54.80%. The percentage category of live coral reef cover is based on the quality standard of the Minister of Environment Decree No. 4 of 2001 with moderate criteria, ranged from 50 - 74.9%.

The percentage of coral reef cover at a depth of 6 meters ranged from 23.03-96.97%. The highest percentage of coral reef cover was at Station 3, Beloi village of 96.97%, while the lowest percentage of coral reef cover was at Station 1 of Vila village of 23.03%. The criteria for the percentage of coral reef cover are in poor condition, referring to the Minister of Environment Decree No. 4 of 2001. Percentage of coral reef cover in Acrema Village there is 40.03% which is categorized in the "moderate" category, coral reef cover in Beloi village is 74.22% which is categorized as "Good", while Vila village is categorized as good with a coral cover presentation of 50.15%.

Table 6. The number and composition of fish

Group	Location						In Total	
	Beloi		Vila		Biqueli			
	N	%	N	%	N	%	N	%
Mayor	137	46.28	117	57.07	123	60.59	377	53.55
Target	139	46.96	72	35.12	65	32.02	276	39.2
Indicator	20	6.76	16	7.8	15	7.39	51	7.24
Total	296	100	205	100	203	100	704	100

Remarks: N = Total number of fish; % = Composition

Based on the results of the analysis of reef fish observations carried out in the Ataúro Island, it showed that the major fish groups were the most dominant, with the total reef fish 377 fish (53.55%), then the target fish groups were 276 fish (39.20%) and the indicator fish groups were as many as 51 (7.24%). The results of the analysis for composition of fish species at each observation location showed that the Beloi village had 137 major fish groups (46.29%), 129 target fish groups (46.98%) and 20 indicator fish groups (6.76%). Vila village with 205 fish, dominated by 117 major fish (57.07%) and followed by 72 target fish (35.12%) while in Biqueli village there are 203 fish with fish group Major fish dominated the observation location with 123 fish (60.59%), 65 target fish group (32.02%) and the least fish group was indicator fish group with 15 fish (7.39%).

The results of the analysis diversity of reef fish species in the waters of Beloi Village show that the diversity index (H') of major fish species is 3.47, target fish is 2.50 and indicator fish is 2.50. Diversity index of $2<H'<3$ indicates that the level of diversity of the target and indicator fish species is categorized as 'medium', while the major fish have a "High" diversity index value of 3.47. The reef fish evenness index was at an average value of 1.0, indicating that the reef fish community in the waters of Beloi Village was in a 'High' stability stage. The fish group dominance index in Beloi village with an average value of 1.0 was categorized as “High Dominance”, namely the *Pomacentrus vaiuli* fish species from the *Pomacentridae* family.

Table 7. Diversity, Evenness, and Dominance indices

Village	Index	Group of Coral Fish				Stability Stage
		Mayor	Target	Indicator	Average	
Beloi	Diversity index (H')	3.47	2.5	2.5	2.8	Moderated
	Evenness index (E)	1.04	0.74	1.2	1	High
	Dominance Index (C)	0.41	1.41	1.22	1	High
Vila	Diversity index (H')	3.06	3.43	2.29	2.9	Moderated
	Evenness index (E)	0.89	1.13	1.17	1.1	High
	Dominance Index (C)	0.58	1.72	0.98	1.1	High
Biqueli	Diversity index (H')	3.27	3.61	2.5	3.1	High
	Evenness index (E)	1	1.25	1.4	1.2	High
	Dominance Index (C)	1.24	1.12	1.31	1.2	High

Thus, reef fish communities will easily experience threats or pressure if they get natural ecological disturbances. The diversity index of fish groups in Vila village with an average value of 2.9 which can be categorized in the medium diversity index, the major fish group has a diversity index value of 3.06 in the high category, the target fish group has a value of 3.34 which is categorized in the high diversity index and the indicator fish group is categorized medium because it has a value of 2.29.

Table 8. Carrying Capacity

Carrying Capacity	Biqueli	Beloi	Vila/Maumeta
K	2	2	2
Lp (m^2)	5200	8400	7400
Lt (m^2)	2000	2000	2000
Wt (s)	8	8	8
Wp (s)	2	2	2
DDK (person/day)	21	34	30

The carrying capacity for marine ecotourism can be seen from the existence of activities that are only found in 3 locations on the island of Ataúro, namely Biqueli, Beloi and Vila Villages. The following is the analysis of the carrying capacity of the marine area based on the ecotourism category on the Ataúro Island. Based on the results of observations and information from marine ecotourism management officers at the location, tourist activities are usually at 08:00 WIB in the morning until around 16:00 WIB. Thus, it can be assumed that the time available for tourists to carry out diving tourism activities (Wt) on Ataúro Island is 8 hours/day. The value carrying capacity for diving ecotourism on the Ataúro Island is

presented in the table above. It shows that the highest carrying capacity in Beloi village of 34 people/day and the lowest is ABiqueli village of 21 people/day. Carrying capacity at these three stations got the lowest score due to the narrow expanse of coral reefs that affected the carrying capacity value for diving ecotourism. The statement in question is in accordance with the opinion of previous research that diving ecotourism considers the wide expanse of coral reefs to be able to enjoy the beauty of corals from above the water surface and have high brightness [13] [15]. Carrying capacity of ecotourism is a paradigm for overcome and limit the number of activities specific marine ecotourism development for maintain local communities and cultural and environmental contexts, and also is a recreational capacity as a means of formulate problems and actions management resulting in impact reduction.

Table 9. Ecotourism Stability Index Category Diving

Village	Ecotourism Suitability Index (%) Category Diving
Beloi	75.93
Vila	66.67
Biqueli	61.11

The results of analysis of the ecotourism suitability index for the diving category show that the highest value is found in Beloi village of 75.93% which is categorized as "Very Appropriate" and the lowest is in Acrema village of 61.11% which can be categorized as "Appropriate" while the ecotourism suitability index value in Vila village is 66.67% which categorized as "Appropriate". The low ecotourism suitability index value in Biqueli village is due to the very fast current speed of 33 cm/second, thereby reducing the ecotourism suitability index value. This condition is very much different from previous research (Dahuri, 2003) which states that the optimal current speed for diving is in the range of 0-15 cm/second [16]. Based on the marine ecotourism suitability index matrix of Beloi village, the ecotourism suitability index value is categorized as very suitable to be used as ecotourism. And marine ecotourism suitability index for Vila 66.11%, Biqueli 61.11% index which is show that the suitability of marine ecotourism is appropriate for a potential marine tourism.

4 Conclusion

Were the water quality in the three location has a different range of water quality, within the tolerance level of coral reef life, thus, the percentage of coral reef cover has a good category, however in Biqueli village in the moderate category. The diversity of coral reef fish associations in this study is very varied and is dominated by *Pomacentrus vaiuli* species from the Pomacentridae family, carrying capacity for category diving has a different value per village which is Biqueli 21 carrying capacity, Beloi 34 carrying capacity and lastly Vila 30 carrying capacity for diving. However, in general, marine ecotourism suitability index for category diving in Ataúro Island has appropriated category for potential marine ecotourism.

Marine ecotourism diving category is closely linked to the existence of coral reef ecosystems. The tourist who visits the marine ecotourism they offer new challenging experiences and beautiful underwater landscapes. Relatively weak currents are ideal conditions for diving marine ecotourism It's about the comfort and safety of tourists. Coral reef depth is related to water quality such as water movement, temperature, and salt content, and is generally the appropriate depth for a coral reef ecosystem to grow is 10 to 15 meters, but in Ataúro Island at a depth of 6 m has been found beautiful coral, this is very unique owned by the Ataúro Island.

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