Development analysis of mangrove ecotourism land suitability and carrying capacity of the mangrove area of Bebanga, Mamuju Regency, West Sulawesi Province

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Abstract. The Mangrove Ecosystem Area of Bebanga is one of the protected forest areas in West Sulawesi. Coastal areas tend to be over-exploited, usually impacting the sustainability of resources and the environment. Thus, tourism development must consider aspects of carrying capacity to maintain natural sustainability and for the welfare of the community. Ecotourism is an environmentally friendly activity that can improve the welfare of life, which can actually provide income to local communities. The purpose of this research was to determine the suitability of mangrove ecotourism land, including mangrove thickness, mangrove density, mangrove species, tides and biota, as well as to calculate the carrying capacity of the mangrove area of Bebanga. A descriptive quantitative analysis was carried out through field observations for three months from August to October 2020, in three research stations. From the results of the analysis, the suitability of the area is included in the appropriate category (S2) for mangrove ecotourism, with a value of 71,79%; the surface of the area that can be used is 2 ha, if the tourist spot is open for 12 hours daily; the carrying capacity of the area is 286 people per day.
Key Words: rehabilitation, sustainable ecotourism, tourism suitability index.

Introduction. The mangrove ecosystem provides a number of ecological functions, being one of the main producers in marine fisheries. The development its potential will have a direct role in the state of the coastal ecosystem, where the mangrove ecosystem is important physically, biologically and economically for the community (Fitriana et al 2016). The ecological function of a mangrove ecosystem is as a provider of nutrients for aquatic biota, spawning grounds, and nursery for various kinds of biota (Departemen Kehutanan Direktorat Jendral Rehabilitasi Lahan dan Perhutanan Sosial 2005); it also represents a protection against coastal abrasion, preventing the intrusion of sea water, it is a buffer against the seagrass ecosystems and coral reefs and protects coastal communities from natural calamities like tsunamis (Dahdouh-Guebas et al 2005).

The utilization of mangrove ecosystems for ecotourism is in line with the shift in tourist interest from traditional tourism, namely tourists who only come for tours without any elements of education and conservation, to new tourism, namely tourists who come to make tours with elements of education and conservation that can encourage the preservation of mangrove ecosystems as buffer zones in coastal areas (Agussalim & Hartoni 2014; Massiseng et al 2020). According to (Gigovic et al 2016), the concept of ecotourism is very important, because it can contribute to the protection of an area and its development in a sustainable manner. Ecotourism is different from other tourism industries because it is defined as sustainable, able to preserve natural areas, educate tourists about sustainability and provide benefits to local residents (Wood 2002).

The management of the mangrove ecosystem of Bebanga as an ecotourism area has been started since 2013. The natural beauty of mangrove vegetation has become an attractive objective for tourists (Andriyanto 2017), who can participate in non-extractive activities. The diversity of flora includes various species of mangrove trees; fauna is also abundant. Visitors can conduct educational tours in the form of planting mangroves, where ready-to-plant mangrove seedlings are provided free of charge by the manager. Visitors can also enjoy the green of the mangrove forest using the traditional boat of the Mandar Tribe, namely the "Sandeq" boat paddled without a diesel engine or sail. In addition, visitors can learn and help in rehabilitating mangroves, fishing, bird watching, photography, gastronomy and others (Malik et al 2019).

Understanding the importance of the mangrove ecosystem for the survival of living creatures, it is only natural that management efforts are needed to consider the sustainability and preservation of the mangrove ecosystem when turning it into a mangrove ecotourism area (Fitriana et al 2016). Islet resource-based tourism activities are increasing in demand (Aspiany et al 2019). Therefore, it is necessary to manage resource utilization based on the suitability of tourism areas and aspects of carrying capacity, which is the first step in ensuring the sustainability of tourism development in coastal areas. According to Noor & Romadhon (2020), conformity and carrying capacity analysis is a basic concept developed as one of the efforts for the management of natural resources and the environment conducted sustainably, expected to produce a management direction with the concept of sustainable marine ecotourism (Koroy et al 2017).

Material and Method

Description of the study site. This research was conducted from August to October 2020. The research location was in the mangrove area of Bebanga, Kalukku District, Mamuju Regency of West Sulawesi Province (Figure 1). Geographically, the mangrove area of Bebanga is located at the latitude of 2°36'57.20" and longitude of 118°59'48.29". The area of Bebanga is 64.31 km^2, being 23 km away from the capital city of West Sulawesi Province. It has boundaries bordering Sinyonyoi Village in the north, Tadui Village in the south, and the west side of Makassar Strait and Mamasa Regency in the East (BPS Kecamatan Kalukku 2019).

Experimental design. The data collected in this study are: mangrove thickness, mangrove species, mangrove density, tides and biota. Sampling was carried out by purposive sampling with consideration of vegetation density using the quadrant transect method. Transect lines were made by pulling the transect path using rafia ropes perpendicularly from land to sea along the mangrove ecosystem. Each observation station contained 3 transect lines. Every transect line contained 1 or 2 plots adjusted to the thickness of mangroves. Line transects were made by pulling the transect line using raffia rope perpendicularly from the land to the sea (Poedjirahajoe et al 2017), at a length where there was still a mangrove ecosystem observable. Each transect used a quadratic transect method, with a size of 10x10 m for tree levels, 5x5 m for stake/sapling levels, and 1x1 m for seedling levels (English et al 1998). Each species of mangrove was identified by the type of root and root form, the shape and morphology of the leaves and the reproductive organs and fruits with reference to Noor et al (2012). The species of biota were identified based on Anam & Mostarda (2012) and Kusmana et al (2013). Mangrove thickness was calculated using Google Earth imagery analysis recording from October 2020, and tidal data from 2020 obtained from the Navy Hydrography and Oceanography Center (Pushidrosal).

Supporting capacity analysis is aimed at the development of marine tourism by utilizing the potential of coastal resources, beaches and small islands in a sustainable manner (Koroy et al 2017). The carrying capacity is the maximum number of people who can use an area without disturbing the physical environment, reducing the quality of received services, and not harming the social, economic and cultural aspects of local residents (Zhiyong & Sheng 2009). The calculation of carrying capacity is intended to assess the capacity of visitors who can still be tolerated while the ecosystem can still be maintained (Santoso et al 2016). To maintain natural resources and the environment in a good condition, they need to be managed sustainably (Nugroho et al 2019). According to

Yulianda (2007), the carrying capacity of an area can be calculated based on the ecological potential of visitors determined by the condition of resources and the type of activities developed. The ability of nature to tolerate visitor activities needs to be considered, so that authenticity is maintained. Visitor activity time is calculated based on the length of time visitors spend on sightseeing. Visitor time is seens as the time an area is opened in one day for tourism activities.

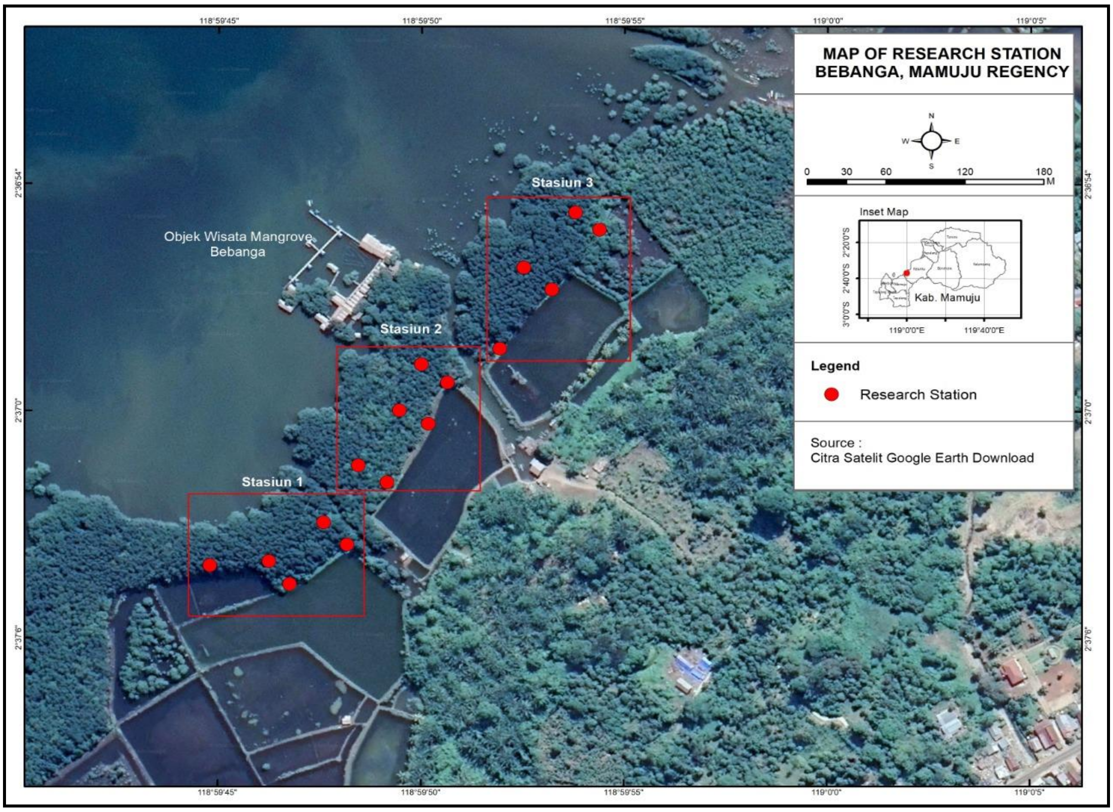

Figure 1. Research location of mangrove area of Bebanga, Indonesia. Map source: Google Earth 2020.

The analysis of tourism area suitability. One way to assess the potential of ecotourism is to use a tourist area suitability method that can ensure the sustainability of an ecotourism area (Pin et al 2021). The suitability of the area can be seen from the percentage level of suitability obtained by the sum of the values of all parameters. To determine the suitability index for mangrove ecotourism, the following equation was used (Yulianda 2007):

$$\mathrm{TSI} = \left[\sum \frac{Ni}{N\,max}\right] x\ 100\ \%$$

Where: TSI - tourism suitability index; Ni - the value of the parameter to-i (weight x score); Nmax - the maximum value of a tourism category.

The mangrove tourism suitability analysis was carried out based on the coastal tourism suitability matrix for mangrove tourism category, taking into account five parameters including mangrove thickness (m), mangrove density (100 m²), mangrove species, tides (m), and biota. The determination of its suitability is based on the multiplication of scores and weights obtained from each parameter (Yulianda 2007). The suitability of the region is seen from the percentage level of conformity obtained by the sum of values of all parameters. The matrix of the suitability of coastal tourism for the mangrove tourism category can be seen in Table 1.

Table 1

Suitability matrix for coastal tourism in the mangrove tourism category

Parameters	*Weight*	*Conformity class (Score)*							
		S1	*Score*	*S2*	*Score*	*S3*	*Score*	*N*	*Score*
Mangrove Thickness (m)	5	>500	3	>200-500	2	50-200	1	<50	0
Mangrove Density (100 m²)	3	>15-25	3	>10-15	2	>5-15	1	<5	0
Mangrove species	3	>5	3	3-5	2	1-2	1	0	0
Tides	1	0-1	3	>1-2	2	>2-5	1	>5	0
Biota	1	fish, shrimp, crabs, molluscs, reptiles, birds	3	fish, shrimp, crabs, molluscss	2	fish, molluscs	1	One of the aquatic biota	0

Source: modifications from Yulianda (2007).

The area suitability level is divided into four classifications, namely: S1 - very appropriate, with a value of 75-100%; S2 - appropriate, with a value of 50-74%; S3 - conditionally appropriate, with a value of 25-49%; N - not appropriate, with a value of 0-25%.

Carrying capacity of mangrove ecotourism area. Area carrying capacity is the maximum number of visitors who can physically be accommodated in a designated area at a certain time without disturbing nature and other humans. Carrying capacity was determined using the following formula (Yulianda 2007):

$$CC = k \; x \; \frac{Lp}{Lt} \; x \; \frac{Wt}{Wp}$$

Where: CC - carrying capacity (person per day); k - the ecological potential of visitors per unit area (person); Lp - Area per length of the usable area (m² or m); Lt - unit area for a certain category (m² or m); Wt - time provided by the area for tourism activities in one day (hour); Wp - time spent by visitors for any particular activities (hours).

Results and Discussion

Species and density of mangroves. Based on field observations at the research location, 7 seven species of mangrove were found in the mangrove ecosystem of Bebanga (Table 2). The mangroves are: *Bruguiera gymnorrhiza, Rhizophora mucronata, Rhizophora apiculata, Ceriops tagal, Sonneratia alba, Avicennia marina and Xilocarpus granatum.* In addition, there are also two species (*Rhizophora stylosa and Sonneratia caseolaris*) that were not found in this study, but were found by (Malik et al 2019) and (Andriyanto 2017), due to different observation stations selected.

Table 2

Mangrove species found in the current study

Station	*Numbers of plots*	*Species*
I	5	*Bruguiera gymnorrhiza, Rhizophora mucronata, Rhizophora apiculata, Sonneratia alba, Xylocarpus granatum*
II	6	*Bruguiera gymnorrhiza, Rhizophora mucronata, Rhizophora apiculata, Sonneratia alba, Xylocarpus granatum, Ceriops tagal, Avicennia marina*
III	5	*Bruguiera gymnorrhiza, Rhizophora mucronata, Rhizophora apiculata, Sonneratia alba, Avicennia marina*

In Station I, *R. mucronata* and *R. apiculata* were most frequently encountered. The density value of the mangroves in Station I was 15 trees 100 m^{-2}. Station II had the highest density value due to the abundance of the species of *R. apiculata* and *C. tagal*. The density value of the mangrove ecosystem at station II was 17 trees 100 m^{-2}. At station III, the most common mangrove species were *R. mucronata* and *R. apiculata*. This condition was the same as that found in Station I, with the density value of 15 trees 100 m^{-2}. Thus, the average value obtained for the density of mangroves from all stations is 16 trees 100 m^{-2}. Based on the suitability matrix for coastal tourism in the mangrove tourism category for the density parameter, the ecosystem is included in the S1 category (very appropriate).

Mangrove thickness. From the results of the analysis of Google Earth satellite imagery (recorded on October 16th, 2020), based on the results of calculations at each station, the thickness of mangroves ranges from 46 to 94 m, with an average value of 74 m. Based on the matrix of suitability of beach tourism, the mangrove tourism category for thickness parameters is S3 (conditionally appropriate).

Biota. The mangrove area of Bebanga has several associated biota in the mangroves. The species of animals or biota found are: birds, fish, reptiles, molluscs and crustaceans. Based on field observations, the bird species found were: river kingfisher (*Halicon cloris*), small egrets (*Egretta garzetta*), "benjut" ducks (*Anas gibberifrons*) and swallows (*Collocalia fuciphaga*). In addition to the bird species found in this study, black eagle (*Ictinaestus malayensis*) and hornbills (*Buceres vigil*) were found by (Andriyanto 2017) and *Collocalia* sp. and *Ciconia* sp. were found by (Malik et al 2019) in the same mangrove forest. The presence of bird species in the mangrove area of Bebanga provides special preoccupations (Andriyanto 2017).

The reptiles found at the research site were: monitor lizards (*Varanus salvator*) and other lizards (*Dasia* sp.). In addition, there were species of estuarine or saltwater crocodiles (*Crocodylus porosus*) found by (Andriyanto 2017) and *Cerberus* sp. and *Chrysopelea* sp. found by (Malik et al 2019) in the same region. Four species of fish were found including: mudskipper (*Periophthalmus* sp.), halfbeak (*Hemiramphus lutkei*), blue-spot mullet (*Valamugil engeli*) and banded archerfish (*Toxotes jaculatrix*). 8 species of molluscs were found: blood clams *(Anadara granosa)*, *Terebralia sulcata*, *Telescopium telescopium*, *Nerita squamulata, Sphaerassiminea miniata, Isognomon ephippium, Chicoreus capucinus* and *Sulcospira testudinaria*. The crustaceans found were climbing crabs (*Episesarma* sp.), climbing purple crabs (*Metopograpsus* sp.), *Uca sp.*, mud crabs (*Scylla serata*) and white shrimp (*Litopenaeus vannamei*). Based on the mangrove ecotourism suitability matrix, the parameters of the biota at each station are categorized in S1 (very appropriate for mangrove ecotourism).

Tides. Based on the results of tidal calculations and on the information from the Indonesian Navy's Hydrographic and Oceanographic Center (Pusat Hidrografi dan Oseanografi TNI Angkatan Laut 2020), a value F of 0.17 was obatianed. This value indicates that the tide in Mamuju Regency is mixed semi-diurnal. This is in accordance with the results of Adibrata (2007), where the tide in Karampuang Island, Mamuju Regency, is mixed with multiple daily skews (F=0.56). This condition shows that there are two high tides and two low tides in one day, but the heights and periods are different. The highest water level is at 2.18 m, while the lowest water level is at -0.18 m. The average high water level is 1.13 m and the average low water level is 0.87 m. The average tidal range is 1.6 m. Based on the suitability matrix of mangrove ecotourism, the tidal parameters of Mamuju Regency at each station are categorized as S2. The tide chart can be seen in Figure 2.

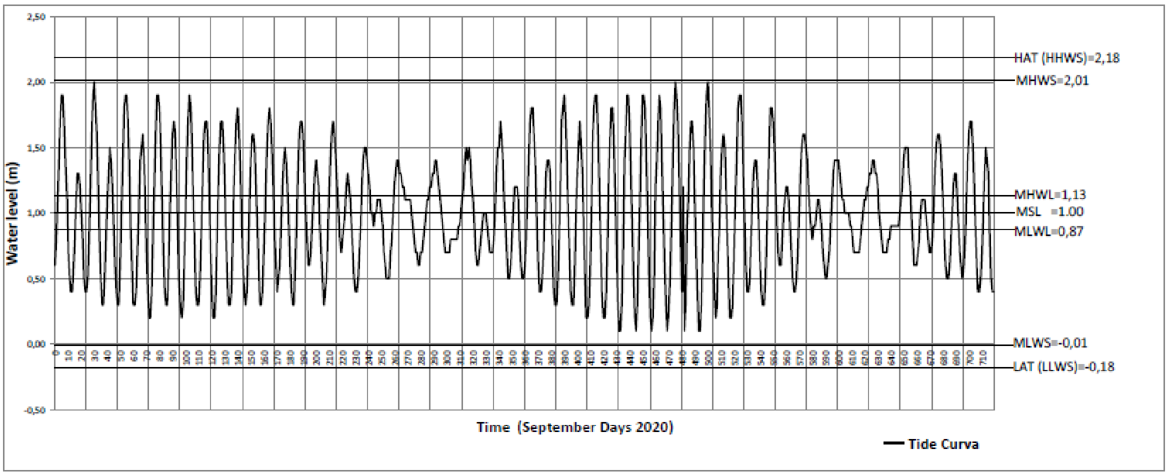

Figure 2. Tide charts from 1 September to 30 September, 2020, Mamuju Regency (source: Pusat Hidrografi dan Oseanografi TNI Angkatan Laut 2020).

Mangrove tourism suitability analysis. The value of tourism suitability based on the suitability matrix of mangrove ecotourism are presented in Table 3.

Table 3

Mangrove tourism conformity analysis results

Parameters	*Weight*	*Category*	*Score*	*Value*
Mangrove thickness (m)	5	S3	1	5
Mangrove density (100 m²)	3	S1	3	9
Mangrove species	3	S1	3	9
Tides (m)	1	S2	2	2
Biota	1	S1	3	3
Amount				28

The suitability index value of mangrove ecotourism area presented in Table 3 shows that the feasibility level of mangrove ecotourism. The parameter values calculated based on mangrove species, mangrove density and biota are in the 'very appropriate' category (S1); tidal parameters belong in the 'appropriate category' (S2), while mangrove thickness is included in the 'conditionally appropriate' category (S3). From the results of the overall calculation, the mangrove area of Bebanga has a value of 71.79%, which is included in the appropriate category (S2) to be used for mangrove ecotourism.

To support mangrove ecotourism activities in the mangrove area of Bebanga, various efforts need to be made to increase the suitability value in this area. Thickness parameters are of particular concern (Nugroho et al 2019), because thick and dense mangrove stands will form a microclimate which, in turn, will reduce temperatures, making tourism more comfortable. In addition, the thickness of mangroves also supports ecotourism activities such as tracking and photography. Thus, it is necessary to plant mangroves in places that allow the increase of the mangrove area, to maintain the role of mangrove ecosystems in ecologic and economic aspects. Various parties need to support this endeavor (Murtini 2017) through rehabilitation programs, by considering planting sites based on seawater level, substrate elevation, and the duration of inundation that affects the success of the rehabilitation (Rini et al 2018; Jalil et al 2020). In this case, the West Sulawesi Provincial Government has made efforts to increase conservation area protection activities related to the policy of Management of Coastal Areas and Islets, namely by developing and improving conservation and rehabilitation programs for coastal ecosystems, especially mangroves, seagrasses and coral reefs along with the community and the private sector by means of prohibition of all activities that can threaten the sustainability of mangrove ecosystems, seagrass, coral reefs and protected forests, such as illegal logging for land clearing (Pokja RZWP-3-K 2017). Therefore, it is hoped that the management of the Mangrove Ecotourism Area of Bebanga can be carried out sustainably based on the principle of ecotourism that harmonizes between environmental management, ecosystem management and development of mangrove ecotourism to improve the welfare of local communities (Agussalim & Hartoni 2014).

Ecotourism management is more emphasized on environmentally friendly tourism activities by prioritizing aspects of nature conservation, aspects of socio-cultural and economic empowerment of local communities as well as aspects of learning and education. Ecotourism emphasizes the importance of ecological conservation without neglecting the socio-economic interests of local communities. The essence of ecotourism is to preserve, but also profit on the nature and culture of the communities. Ecotourism does not exploit nature, but only uses nature and community services to meet the knowledge, physical and psychological needs of tourists. From an economic standpoint, ecotourism creates jobs in remote and underdeveloped areas. The emphasis of ecotourism on local resources and job opportunities makes ecotourism an opportunity for countries that are developing and have high natural potential (IPB 2014).

Heretofore, various environmental problems that have occurred include abrasion, sedimentation, sea water pollution and flooding (Kusmana & Sukwika 2018). This phenomenon is in accordance with several research results related to the destruction of mangrove forests, where people cut mangrove trees excessively for charcoal production and change the function of land to ponds, rice fields or settlements (Macintosh et al 2002; Sodikin et al 2017). Through community participation in managing mangrove forests, public awareness of the surrounding environment can be increased, because the community will think about, formulate, plan, implement, monitor and evaluate their needs, both in terms of protection, utilization of products and rehabilitation of the mangrove ecosystem itself (Amal & Baharuddin 2016). The community should be involved in the rehabilitation program starting from the planning, implementation, evaluation and enjoyment of the results (Erwiantono 2006).

According to (Singgalen 2020), the utilization of mangrove forests through community-based ecotourism can improve sustainable livelihoods. This is also in accordance with the opinion of (Rudianto et al 2019), who state that the role of the community has an influence on the management of coastal areas, improving management of coastal areas with a better participation. Direct community involvement is needed in managing mangrove ecosystems, so that natural conditions and marine ecosystems are not damaged. Some experiences in developing tourism areas that apply the ecotourism concept show an increase in the economy as an impact of tourism activities. For example, ecotourism in Bahoi Village, West Likupang District, North Minahasa Regency, plays an important role in the survival of the community, because the community is able to gain more income, knowledge and experience from ecotourism activities (Liap et al 2019). Direct income through ecotourism come from some opportunities for local people, like tour guides, food sellers, boat rentals and home stay services. Indirect income for people not involved in ecotourism includes benefits from buying food, drinking and various handcrafts sold.

The development of ecotourism in the mangrove ecotourism of "Kampoeng Kepiting" located in Tuban Village, Badung Regency improved the economic condition of the community (Wardani et al 2017). Ecotourism provides job opportunities for the community, involving restaurants, aquaculture, marketing, processing of mangrove fruits, cultural programs, educational and tourism activities, etc. (Wardani & Anom 2017).

Sustainable ecotourism can solve problems in tourism management of the islets of Indonesia, focusing on maintaining the existence of sustainable resources and providing alternative livelihoods for local communities (Aspiany et al 2019). According to Tuwo (2011), sustainable management is a strategy to utilize the capacity of natural ecosystems, does not disturb the natural resources in it, and provides sustainable benefits for human life. The management of the mangrove area of Bebanga in a sustainable manner can be carried out by integrating all aspects that accommodate all interests in a multidimensional manner, namely ecological aspects, economic aspects, social aspects and institutional aspects (Muhsimin et al 2018). Management shouldtake into consideration the carrying capacity of the area, it should minimize damage and ensure the sustainability of resources and the environment, and strengthen institutions for the protection of mangrove forest resources (Liap et al 2019). The economic aspect is seen in improving the welfare of local communities by following the principles of responsible management and commitment to environmental sustainability. The social aspect is seen in community relation activities in managing local resources in a sustainable manner, as well as in increasing public awareness and appreciation of the environment. The institutional aspect is a planned function or role that grows from the community or government/related stakeholders. As the need for cooperation in mangrove management services between all responsible levels, it needs to be improved to achieve sustainability.

The carrying capacity of the mangrove ecotourism area. The carrying capacity in the mangrove of Bebanga was 240 people per day and 46 people per day for tracking (Yulianda 2007). The average time spent by visitors is 2 h, while the time provided by the tourism area in one day is 12 h (starting from 06 am and closing at 06 pm). The tracking length was 380 m, with an area of mangroves of 2000 m^2 that can be utilized. The tracking path is a special attraction for every visitor, so its use must be adjusted to the carrying capacity of the area. According to Rini et al (2018), the length of the tracking facility must pay attention to the carrying capacity of the area and the length of the area used, because the tracking path is a spot of interest to visitors considering the level of vulnerability and limited space.

Carrying capacity is one of the strategies of sustainable tourism management (Muhammad et al 2012). According to (McCool & Lime 2001), carrying capacity is a paradigm in overcoming and limiting the number of certain tourism development activities to maintain local communities, cultural contexts and the environment, as well as recreational capacity as a method of formulating problems and management actions that lead to reduced impacts. Carrying capacity is a basic concept developed for the management of a natural resource and a sustainable environment, through a measure of its capacity (Clivaz et al 2004). Based on the results of interviews with the manager, it is known that the average number of visitors per day is 10 people. This value is still smaller than the carrying capacity value of the mangrove ecotourism route of Bebanga (46 people per day). But for certain days such as Eid holidays and New Year, the number of visitors can exceed the carrying capacity of mangrove ecotourism routes. At the end of 2020, the number of visitors was as many as 50 people, and on Eid holidays in 2019, the number of visitors reached 200 people in two days. According to the area capacity, the number of visitors allowed is 240 people per day, but the tracking path capacity is exceeded by the carrying capacity of the tourist area. This condition can cause damage to the mangrove ecosystem. In addition, the increasing number of visitors who litter with waste can disturb comfort while in the area (Paulus at al 2020). According to (Pickering & Hill 2007), if the number of tourists visiting is not limited in tourism activities, this could threaten the sustainability of the resource itself. Excess visits will certainly reduce the quality of the ecotourism area. Therefore, adequate supervision and management is needed to prevent environmental damage to mangrove ecosystems (Saru et al 2109). Given the level of vulnerability and limited space, it is necessary to regulate the number of visitors (Zulia et al 2019).

To minimize environmental damage, it is necessary to create a better strategy. For example, some suggestions could be adding a tracking area in locations that are inundated by water, without damaging nature by cutting down mangrove trees, so that the visitor capacity can increase, increasing the price of tickets on holidays, and the addition of more trash cans to avoid litter. With the concept of carrying capacity, it is hoped that the utilization of ecotourism will be able to prevent damage to natural resources and the environment. Efforts to manage natural resources and the environment in a sustainable manner can be carried out while still paying attention to the welfare of resource users (Nugroho et al 2019).

Conclusions. From the results of the suitability analysis of the mangrove area of Bebanga, it can be concluded that it is in the very appropriate category (S2) to become a mangrove ecotourism area. Based on the tourism suitability analysis, the mangrove area of Bebanga is included in the appropriate category for mangrove ecotourism. For this reason, it is necessary to add some attractions, to repair and improve facilities and infrastructure, to increase human resources for ecotourism and to carry out rehabilitation and manage the number of tourists visiting.

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Conflict of Interest. The authors declare that there is no conflict of interest.

References

Adibrata S., 2007 [Tide analysis on Karampuang Island, West Sulawesi Province]. Aquatic Journal of Aquatic Resources 1(1):1–6. [In Indonesian].

Agussalim A., Hartoni, 2014 [The potential of mangrove suitability as a coastal ecotourism area]. Journal of Maspari 6(2):148-56. [In Indonesian].

Amal, Baharuddin I. I., 2016 [Community based management of mangrove forest in suppa district, the Regency of Pinrang]. Scientific Pinisi 2:1-7. [In Indonesian].

Anam R., Mostarda E., 2012 Field identification guide to the living marine resources of Kenya. FAO Species Identification Guide for Fishery Purposes, 422 p.

Andriyanto B., 2017 [Mangrove ecotourism development strategy of Bebanga Village, Kalukku District, Mamuju Regency of West Sulawesi Province]. Thesis, Open University, Jakarta, Indonesia, 265 p. [In Indonesian].

Aspiany, Anggoro S., Purwanti F., Gunawan B. I., 2019 Strategies for sustainable ecotourism development in the Marine Waters of Bontang City, Indonesia. AACL Bioflux 12(5):1779-1787.

Clivaz C., Hausser Y., Michelet J., 2004 Tourism monitoring system based on the concept of carrying capacity – The case of the regional natural park Pfyn-Finges (Switzerland). Working Papers of the Finnish Forest Research Institute 2, pp. 230-235.

Dahdouh-Guebas F., Jayatissa L. P., Di Nitto D., Bosire J. O., Lo Seen D., Koedam N., 2005 How effective were mangroves as a defence against the recent tsunami? Current Biology 15(12): R443-R447.

English S., Wilkinson C., Baker V., 1998 Survey manual for tropical marine resources. Second Edition. Australian Institute of Marine Science, 408 p.

Erwiantono, 2006 [A study of community participation levels in Mangrove ecosystem management in the Pangpang Bay Area of Banyuwangi]. Epp 3(1):44-50. [In Indonesian].

Fitriana D., Johan Y., Renta P. P., 2016 [Suitability analysis of mangrove ecotourism in Kahyapu Village of Enggano Island]. Enggano Journal 1(2):64-73. [In Indonesian].

Gigovic L., Pamucar D., Lukic D., Markovic S., 2016 GIS-Fuzzy DEMATEL MCDA model for the evaluation of the sites for ecotourism development: A case study of "Dunavski kljuc" region, Serbia. Land Use Policy 58:348-365.

Jalil A. R., Malik A., Nurdin N., Saru A., Yunus I., 2020 Assessment of seawater level, inundation duration and substrate elevation for mangrove rehabilitation program in the Spermonde Archipelago South Sulawesi Indonesia. International Journal of Conservation Science 11(4):1115-1126.

Koroy K., Yulianda F., Butet N. A., 2017 [Development of marine ecotourism based on islet resources on Sayafi and Liwo Islands, Central Halmahera Regency]. Journal of Fisheries and Marine Technology 8(1):1-17. [In Indonesian].

Kusmana C., Setiawan., Lestari D. F., Meidilaga, Ardha M. J., Wulandari R. R., Permana R. A., Yahdi D. I. P., 2013 [Encyclopedia of mangrove fauna in the forest area of Angke Kapuk, North Jakarta, DKI Jakarta Province]. Cooperation of PT Kapuk

Naga Indah with the Faculty of Forestry, Bogor Agricultural University, 159 p. [In Indonesian].
Kusmana C., Sukwika T., 2018 Coastal community preference on the utilization of mangrove ecosystem and channelbar in Indramayu, Indonesia. AACL Bioflux 11(3):905-918.
Liap A. L., Masyhudzulhak, Saluy A. B., 2019 [Management of ecotourism sustainable mangrove forest]. Proceedings of the National Seminar on Higher Education Quality Improvement, pp. 129-134. [In Indonesian].
Macintosh D. J., Ashton E. C., Havanon S., 2002 Mangrove rehabilitation and intertidal biodiversity: A study in the Ranong mangrove ecosystem, Thailand. Estuarine, Coastal and Shelf Science 55(3):331-345.
Malik A., Rahim A., Sideng U., Rasyid A., Jumaddin J., 2019 Biodiversity assessment of mangrove vegetation for the sustainability of ecotourism in West Sulawesi, Indonesia. AACL Bioflux 12(4):1458-1466.
Massiseng A. N. A., Tuwo A., Fachry M. E., Bahar A., 2020 A dynamic simulation of mangrove ecotourism management at the Lantebung of Makassar City. IOP Conference Series: Earth and Environmental Science 584:012039, 11 p.
McCool S. F., Lime D. W., 2001 Tourism carrying capacity: Tempting fantasy or useful reality? Journal of Sustainable Tourism 9(5):372-388.
Muhammad F., Basuni S., Munandar A., Purnomo H., 2012 [The study of carrying capacity in mangrove ecotourism Blanakan, Subang, West Java]. Biome: Periodic Scientific Biology 14(2):64. [In Indonesian].
Muhsimin, Santoso N., Hariyadi, 2018 [Sustainability management status of mangrove ecosystem in coastal area of Akuni Village District of Tinaggea, South Konawe Regency]. Journal of Tropical Silviculture 9(1):44-52. [In Indonesian].
Murtini S., 2017 [Suitability and carrying capacity of mangrove ecotourism of Wonorejo, Surabaya City]. Proceedings of the National Seminar Management of Maritime Potensial of Indonesia, pp. 220-227. [In Indonesian].
Noor M. A. F., Romadhon A., 2020 [Analysis of the suitability and environmental carrying capacity of Gili Noko Bawean Island as a coastal ecotourism area]. Juvenil: Scientific Journal of Marine and Fisheries 1(1):38-46. [In Indonesian].
Noor Y. R., Khazali M., Suryadiputra I. N. N., 2012 [Mangrove introduction guide in Indonesia]. Directorate General of PHKA, Wetlands International-Indonesian Programme, Bogor, Indonesia, 220 p. [In Indonesian].
Nugroho T. S., Fahrudin A., Yulianda F., Bengend D. G., 2019 [Land suitability and carrying capacity analysis of the mangrove ecotourism at Muara Kubu Mangrove Areas, West Kalimantan]. Journal of Natural Resources and Environmental Management 9(2):483-497. [In Indonesian].
Paulus C. A., Soewarlan L. C., Ayubi A. A., 2020 Distribution of marine debris in mangrove ecotourism area in Kupang, East Nusa Tenggara, Indonesia. AACL Bioflux 13(5):2897-2909.
Pickering C. M., Hill W., 2007 Impacts of recreation and tourism on plant biodiversity and vegetation in protected areas in Australia. Journal of Environmental Management 85(4):791-800.
Pin T. G., Supriatna J., Takarina N. D., Tambunan R. P., 2021 Mangrove diversity and suitability assessments for scotourism in Cimalaya Wetan Coast, Karawang District, Indonesia. Biodiversitas 22(2):803-808.
Poedjirahajoe E., Marsono D., Wardhani F. K., 2017 [Use of principal component analysis in spatial distribution of mangrove vegetation on the North Coast of Pemalang]. Journal of Forestry Science 11(1):29-42. [In Indonesian].
Rini, Setyobudiandi I., Kamal M., 2018 [Assessment of suitability, carrying capacity and ecotourism activities in the mangrove area of Lantebung, Makassar City]. Journal of Tourism 5(1):1-10. [In Indonesian].
Rudianto, Larasati A. P., Yusuf F. R., Parawiranata W., 2019 A comprehensive assessment of the role of stakeholders in the management of Wanamina Island in Sidoarjo, East Java Province, Indonesia. AACL Bioflux 12(1):250-260.
Santoso A. B., Kurniawan E., Syifauddin M., 2019 The development of eco-edutourism

village in mangrove Tapak Forest Area, Tugurejo, Tugu sub-district as a community-based tourism. 313:328-333.
Saru A., Idrus R., Ilham M., 2019 The mangrove ecosystem potential for educational tour development around pond education of Hasanuddin University (Unhas) in Mallusetasi District, Barru Regency. Jurnal Ilmu Kelautan SPERMONDE 5(2):70-76.
Singgalen Y. A., 2020 Mangrove forest utilization for sustainable livelihood through community-based ecotourism in Kao Village of North Halmahera District. Jurnal Manajemen Hutan Tropika 26(2):155-168.
Sodikin, Sitorus S. R. P., Prasetyo L. B., Kusmana C., 2017 Spatial analysis of mangrove deforestation and mangrove rehabilitation directive in Indramayu Regency, West Java, Indonesia. AACL Bioflux 10(6):1654-1662.
Susanto R. B., Yoza D., Arlita T., 2016 [The potential and carrying capacity ecotourism area of mangrove forest Bandar Bakau Dumai]. JOM Faperta UR 2:99-102. [In Indonesian].
Tuwo A., 2011 [Management of coastal and marine ecotourism of ecology approaching, socio-economy, institutions, and regional facilities]. Brilliant International, Sidoarjo, Indonesia, 412 p. [In Indonesian].
Wardani I. G. M. I. S., Anom I. P., 2017 [The socio-economic impact of mangrove ecotourism management of crab village on fishermen in Tuban Village, Badung Regency]. Journal of Tourism Destinations 5(1):72-77. [In Indonesian].
Wood M. E., 2002 Ecotourism: Principles, practices & policies for sustainability. United Nation Publication, 32 p.
Zhiyong F., Sheng Z., 2009 Research on psychological carrying capacity of tourism destination. Chinese Journal of Population Resources and Environment 7(1):47-50.
Zulia M., Supratman O., Sari S. P., 2019 [Suitability and carrying capacity of mangrove ecotourism in Kurau Village and West Kurau Village, Central Bangka Regency]. Aquatic of Waters Resource Journal 13:94-104. [In Indonesian].
*** BPS Kecamatan Kalukku, 2019 [Kalukku district in numbers 2019]. Statistics Central Bureau of Mamuju Regency. Available at: https://mamujukab.bps.go.id/. [In Indonesian].
*** Departemen Kehutanan Direktorat Jendral Rehabilitasi Lahan dan Perhutanan Sosial, 2005. [Guidelines for inventory and identification of critical mangrove land]. Available at https://adoc.pub/departemen-kehutanan-direktorat-jenderal-rehabilitasi-lahan. [In Indonesian].
*** https://www.google.com/earth/
*** IPB, 2014 [Study on fisheries based ecotourism planning on Karampuang Island in West Sulawesi Province]. Final report, Institute for Research and Community Service, Bogor Agricultural Institute, Bogor, Indonesia. [In Indonesian].
*** Pokja RZWP-3-K, 2017 [Zoning plan for coastal areas and islets (RZWP-3-K) West Sulawesi Province]. Final report on the zoning plan for coastal areas and islets (RZWP-3-K) West Sulawesi Province. [In Indonesian].
*** Yulianda F., 2007 [Marine ecotourism as an alternative utilization of conservation-based coastal resources]. Science Seminar of the Department of Aquatic Resources Management. FPIK-IPB, Bogor, Indonesia. [In Indonesian].
*** Pusat Hidrografi dan Oseanografi TNI Angkatan Laut (Pushidrosal), 2020 [Tide tables of Indonesian archipelago]. [In Indonesian].

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