DEPIK
Jurnal Ilmu-Ilmu Perairan, Pesisir dan Perikanan
Journal homepage: www.usk.ac.id/depik

Evaluation feasibility and ecological gap in marine conservation area of Southeast Sulawesi Province

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ARTICLE INFO

Keywords:
Conservation area
Feasibility area
Gap
Southeast Sulawesi

DOI: 10.13170/depik. 12.1.31637

ABSTRACT

Aquatic Tourism Park (ATP) of the Southeast Sulawesi Province has significant contribution to achieve the total targeted of 30 million of Marine Protected Areas (MPA) in Indonesia. The conservation area is located in 3 coastal districts of Konawe, South Konawe, and Kendari City Districts. The time-consuming process of legalizing the conservation area has driven the need to re-evaluate the ecological conditions from 2012 to 2020. The objective of this study is to this aims to determine the status, gaps and ecological feasibility of conservation areas in the Southeast Sulawesi region. One of the noticeable gaps is the change of ecological conditions in the reservation area. The gap could be identified by comparing ecological conditions before and after the area was reserved for a conservation area. Ecosystem suitability was measured by using ecological criteria, such as number of protected fish species, mangrove density, seagrass coverage, coral coverage, and naturalness. The score of suitability assessment was 31, which showed that the reserved location was suitable for a Marine Conservation Area. However, gap analysis results showed 10% decline in coral coverage and 17% decrease in seagrass coverage, while mangrove density decreased as much as 102 trees/ha during that period. Evaluation on the ecosystem condition was conducted by applying suitability analysis of the modified E-KKP3K dan Sambah et al. (2020) methods, resulting a status of suitable or conservation area allocation (score 31). Criteria used were chosen based on its contribution in facilitating important ecological processes and as ecosystem buffer system in the area. This study will give the implementation on MPA management optimalisation and it can be contributed on fisheries management.

Introduction

The Ministry of Marine Affairs and Fisheries of the Republic of Indonesia (MMAF) sets a target for (MPA) in Indonesia. In the period of 2009 to 2020, MMAF targeted an area of 20 million hectares (ha) to protect Indonesia's marine biodiversity from various intensifying threats. This target increases to 32.5 million ha by 2030 (KKP, 2021).

In 2020, a total of 201 conservation areas are designated and reserved for 24.11 million ha (KKP, 2021). In 2021, the MPA has reached over 20 million ha which means that the MPA only needs to achieve 5.89 million ha (19.63%) to achieve the 2030 target. Currently, MMAF has reserved an area of 7.3 million ha for the MPA. The current MPA are spread over 201 areas in the western, central and eastern Indonesia. However, further important challenges in Indonesian marine protected area management are not only in term of area, but more on how effective the management of those MPAs (management effectiveness).

One of the MPAs in the eastern region is located in the Southeast Sulawesi Province. This MPA is established based on the Decree of the Governor of Southeast Sulawesi Province Number 98-year 2016 bearing the subject of Aquatic Tourism Park (ATP). The Park is located at the coastal area of Konawe, South Konawe, and Kendari City Districts with an

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p-ISSN 2089-7790; e-ISSN 2502-6194
Received 6 April 2023; Received in revised form 26 April 2023; Accepted 27 April 2023
Available online 28 April 2023

area of 21,786.14 ha. The ATP has been stipulated by Decree of the Minister of Marine Affairs and Fisheries No. 2 year 2009. The Southeast Sulawesi ATP still uses the 2014 basic data.

The initiation team who evaluated the Southeast Sulawesi MPA stated that the chosen area has high potential score. The average live coral reef coverage, seagrass coverage and mangrove density are all above 50%, which is stated as good category (Adnyana, 2014; DKP Sulawesi Tenggara, 2016).

Management in coastal areas has important and strategic roles, by considering that land and sea transitional areas are prone to ecosystem degradation. According to several researches on coastal ecosystem conducted in 2018-2019, the current status of seagrass beds in Indonesian waters is in the unhealthy category, while coral reefs are in the medium category with less biomass, and mangrove forests are in the medium category (LIPI, 2020).

Ecosystem conditions in the Southeast Sulawesi MPA tend to decrease in quality. Excessive use of resources and the application of non-environmentally friendly fishing practices cause the rapid degradation of natural resources (Latuconsina, 2016). A study conducted in 2012 (DKP, 2013) by the Southeast Sulawesi team from the Provincial Office of Marine Affairs and Fisheries on coral reef, seagrass and mangrove ecosystems showed that the coastal ecosystem in the studied area were still in good category, therefore, the team decided to reserve the Southeast Sulawesi MPA as a conservation area.

However, there are indications of degradation of the existing ecosystem within the conservation area. Intense anthropogenic activities around ecosystems have been threatening the sustainability of conservation areas. The use of fish bombs, logging of mangroves trees and construction of ports without considering environmental aspects threats the existence of surrounding ecosystems.

In addition, there are disturbances in the migration flow of turtles and dolphins as protected biota. According to Saputra (2019), Konawe District still serves as the migration areas of dolphins and turtles, with some areas serve as cetacean migration routes. The conservation area in Konawe District is also the habitat of Chelonia mydas (Green Sea Turtle) and Eretmochelys imbricata (Hawksbill Sea Turtle).

As a precautionary measure, it is necessary to formulate appropriate management of coastal areas to ensure the sustainability of the ecosystem and the associated natural resources. Establishment of marine conservation area is a form of area arrangement by prioritizing the protection function. Ecological feasibility assessment of an area is a form of ecological potential verification of an area. Thus, the ecological feasibility assessment plays a very important role in supporting the function of the conservation area.

Conservation area is a form of effort to protect biodiversity, which is established to ensure ecosystems and species protection from anthropogenic activities that damage the environment at the expense of natural resources.

In this study, gap analysis is used to identify gaps in ecological conditions that occurred when using the 2012 baseline data, before the current conditions were set in 2020.

Gap analysis aims to analyze whether ecosystem conditions are under pressure due to anthropogenic activities, causing a decrease in ecosystem quality. The gap analysis is then followed by a process to determine the components that are experiencing degradation, for example habitat conditions are damaged or protected species are no longer observed in conservation areas.

Finally, the information obtained will be used as a baseline to set priorities for conservation actions and in determining the area designs to ensure resource sustainability with appropriate land use (Jennings, 2000). The results of the study must guarantee the protection of ecosystems and endangered species in the conservation area.

The ecological feasibility assessment in conservation reserve area aims to ensure that ecosystem conditions and protected species are represented in conservation areas. The process of verifying ecological conditions must also be carried out to see the feasibility of the area and see the gaps in existing and previous ecological conditions. It is important to analyze in detail the information and ecological existing conditions in a conservation area.

This information serves as basis for the preparation of a management plan for the area. Conservation areas are expected to be able to answer conservation objectives by functioning as life support areas without neglecting the social and economic needs of the community.

According to evidence and problems above this study only use 1 formulated. This study aims to determine the status of the area after being reserved for a long time is still in a state according to standards, look at the level of ecosystem degradation in the Southeast Sulawesi MPA area. This study will give the implementation on MPA management optimalisation and it can be contributed on fisheries management. This research found that there are a

gap status and feasibility for MPA management for fish enrichment within take zone and its spill over within use zone, even though, it still needs to improve mangrove, seagrass and coral reef condition.

Materials and Methods

Location and time of research

The research was carried out from September 2019 to March 2020 in the Southeast Sulawesi Regional MPAs which is located in three administrative cities and districts, i.e., Konawe, South Konawe, and Kendari City.

The conservation area has three important ecosystems and several protected biotas within the area. The ecosystem consists of coral reefs, mangroves, and seagrass beds. The existing protected biota include Napoleon fish (*Cheilinus undulatus*), Hawksbill Sea turtle (*Eretmochelys imbricata*), green sea turtle (*Chelonia mydas*), sea bamboo (*Isis* sp.), and giant clams (*Tridacna* sp.). Around June, spinner dolphins (*Stenella longirostris*) migrate across several MPA areas. Results of research conducted by Tasidale *et al.* (2020) showed that lobster seeds (*Panulirus* spp.) were found in the MPA area. Therefore, this reserve area has a fairly good resource potential.

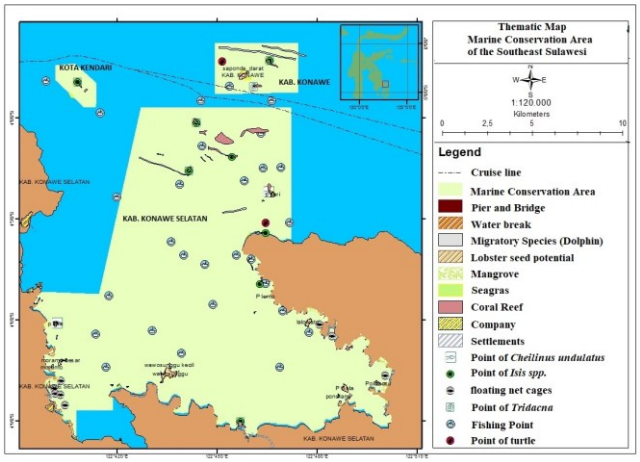

Figure 1 Information map of the Southeast Sulawesi MPA according to Governor's Decree No. 98, 2016 which is located in Konawe District, South Konawe District, and Kendari City.

Data collection and analysis

The data obtained were described quantitatively. Community indices are calculated based on the formula in Begon *et al.* (1990), which includes the Shannon-Winner index (H '), uniformity index (E), Simpson index (D), and equality index (J).

Data collected in this study were secondary and primary data. Secondary data was obtained from Department of Maritime Affairs and Fisheries of Southeast Sulawesi Province. Information on ecological condition of the area at the time the initiated area was assessed. The primary data were directly obtained by conducting water and soil samplings at the observation stations in the Southeast Sulawesi MPAs area.

Coral reef

Primary data on coral reef collection were collected by using the Point Intercept Transect (PIT) method following the method of Manuputty & Djuwariah (2009).

Point Intercept Transect is a method of calculating the coverage percentage (%) using a marked rope with a distance of 0.5 m. PIT method is the most effective method used for monitoring coral reefs (Wahib & Luthfi, 2019). Retrieval of coral reef coverage data is needed to determine the quality and condition of coral reefs at several predetermined stations.

The station refers to the baseline data, which was established to process the feasibility and gap analyses of the Southeast Sulawesi MPA. Recording was carried out on live rock coral reefs. Other biota or bottom substrate was recorded according to their presence under each point.

Categories recorded on the station were stony coral, coded AC and NA, another biota and substrate. There are 7 mangrove stations. 10 seagrass stations, and 16 reef stations (Table 1). The station points were obtained.

The Activities Report on the Identification of Candidates for Marine Protected Areas in the Staring Bay Region of Southeast Sulawesi Province (DKP Sulawesi Tenggara, 2015)

$$\text{Category coverage percentage} = \frac{\text{Number of each component}}{100\ (\text{Total component})} \times 100 \quad \textbf{.....(1)}$$

The process of determining coral reefs condition category is based on the total percentage of live coral reef coverage, which is guided by the coral reef coverage condition category based on the Decree of the Ministry of Environment and Forestry Number 4-year 2001, which states that the condition is divided into four categories, namely damaged/poor, moderate, good and very good.

Table 1. Location station

St.Mangrove	St. Sea grass	St. Coral Reef
D.Labutaone	Pasi Jambe	Pasi Jambe
D.Tambenaga	P.Saponda Island (2 st)	saponda Island (2 st)
D.Woru2	Hari Island	Sapa Hari Island (2 st)
D.Wandaeaha	Tg.Gommo	Saponda Tengah
Mata Air emba	D. Labutaone	Hari Island
D.Tambolosu	D.Tambeanga	Tanjung Gomo
D.Ranooha Raya	Wawosunggu Island	Tanjung Lemo/Labutaone
	Wawosunggu	Woru-Woru
	Lara Island	Gala Island
		Rumbi-Rumbia
		Wawosunggu Island
		Panambea Barata
		Moramo Island
		Lara Island

Mangrove density

Information on the criteria for mangrove quality standard was assessed to determine the value in the gap analysis. Criteria for mangrove quality standard is measured by the changes in the ecological condition of the mangrove ecosystem. The method for collecting data on mangrove community density is line transect method (Bengen, 2001). The data collection at each station consisted of 3 straight line transects starting from seaward to land perpendicular to the coastline. The distance between each transects line was ± 50 m, with each transect line having a 10 x 10 m^2 plot for groups of mangrove trees. Mangroves were included in the category of trees measured at breast height with a diameter of ≥ 10 cm (Ghufrona *et al*., 2015). Density data was calculated following the formula from Fauziah (2004) as follows:

$$\text{Density} = \frac{\text{Number of individu}}{\text{Plot area}} \quad \textbf{(2)}$$

Seagrass coverage

Based on observations at the designated stations, the types, number of species, densities and conditions of seagrass beds were described based on coverage percentage data and seagrass quality standards based on the Decree of the Ministry of Environment and Forestry Number 201-year 2004 concerning quality standards for seagrass status, ranging from poor to healthy seagrass conditions (Figure 1).

The coverage percentage was measured based on the sampling results from the transect. A quadratic transects measuring 100 x 100 cm was divided into 25 sub-plots, measuring 20 x 20 cm. The coverage percentage of seagrass was calculated based on seagrass coverage class. Calculation of seagrass coverage for each plot was done by using the formula as follows:

$$C = \frac{\sum(M_i \, x \, f_i)}{\sum f} \quad \textbf{(3)}$$

where:
C = coverage percentage of seagrass i
Mi = midpoint percentage of seagrass i presence class
f = number of subplots in the same class of seagrass i presence

Protected fish habitat

Data collection for protected fish was carried out using the participatory mapping method and secondary data. Participatory mapping is determined by using the result of discussions with fishermen and communities around the area. The results of this method were reinforced with references.

Data collection using participatory mapping is applied to maps containing information about the distribution of a species, conservation areas and traditional areas (Chambers, 2006).

Protected fish are fish that are protected according to the applicable laws and regulations. The assessment of protected fish is in accordance with the guidelines for Evaluating the Effectiveness of Management of Coastal Waters and Small Islands Conservation Areas (E-KKP3K). The assessment of protected fish is categorized as follows: There are several (> 2) protected fish species = good, there are two protected fish species = sufficient, and there is one type of protected fish = less.

Naturalness

The secondary data were collected from the results of interviews and a map of the Zoning Plan for Coastal Areas and Small Islands (RZWP3K). The parameter of naturalness was assessed by calculating the percentage of human intervention in the ecosystem/habitat concerned for the area concerned. Human intervention is an area that has already been changed, such as cultivation, DPI, floating nets, construction of docks, dredging, stockpiling, embankment construction, waste disposal and others. The naturalness is the area obtained without any activities in that area.

Feasibility analysis for ecology of the area

Area feasibility analysis is used to assess ecological conditions and potential within an area. Coastal areas are generally vulnerable to ecological pressures occurred in certain ecosystems caused by anthropogenic or natural activities. Ecological pressure threatens the sustainability of existing ecosystems and resources (Birawa&Sukarna, 2016).

One form of evaluation is by assessing the ecological conditions in the area, for identifying ecological conditions, whether or not it is still feasible as a buffer for natural resources. Protecting biodiversity in the area is also an absolute reference for maintaining its existence (Sulisyati *et al*., 2019).

Feasibility analysis is also used as an effort to update existing ecological data information in the area. The objective of zoning determination is to update information on potential existence and to support elements in the area (Sambah *et al*., 2020). The feasibility analysis assesses the existing ecological criteria in an MPA to determine the suitability of an area. The criteria used must contribute to the maintenance of important ecological processes or life support systems.

Table 2 Matrix for calculating the feasibility of conservation areas based on ecological conditions.

No.	Criteria	Weight	SL Score (3)	L Score (2)	TL Score (1)
1	Protected endangered fish	4	>2 types	1-2 types	None
2	Mangrove density	3	≥1500	≥1000-<1500	<1000
3	Seagrass coverage	3	>60%	30-49.99%	<29.9%
4	Coral reef coverage	3	50-100%	25-50%	0-25%
5	Naturalness	1	Or > 75%	50 < Or < 75%	Or < 50%

Source: Modification from E-KKP3K Supplement and Sambah *et al.* (2020).

Notes:
Rk = Class range, Si max = Value score x maximum weight of the i-th parameter, Si min = Score value x minimum weight of the i-th parameter.

Assessment of the ecological feasibility of conservation areas uses a matrix to analyze the feasibility of a conservation area based on the specified criteria. The criteria are chosen based on the considerations from the E-KKP3K Supplement module 1, where the reservation stage is still at the identification of potential conservation area candidates and socialization. The matrix is modified by adding weight and score for easily identifying the eligibility of potential conservation area candidates. Supplement 1 relates to the preparation of conditions. The criteria used are based on the existing conditions and also conditions in the Southeast Sulawesi MPA.

Determination of eligibility status is based on the eligibility matrix which is assessed using the calculation of the weight and score of each criterion. The calculation results are then classified into feasibility classes based on the value of each calculated parameter. The class range values for each class of conservation area reservation feasibility include SL (Very Eligible), L (Eligible), and TL (Not Eligible), which are obtained based on the following equation:

$$RK = \frac{\Sigma\,(Si\ max) - \Sigma\,(Si\ min)}{\Sigma\,Class} \quad \textbf{(5)}$$

The feasibility matrix was assessed by considering several ecological criteria contained in the Southeast Sulawesi MPAs. Ecological criteria and weights were determined based on conditions in the conservation area. The criteria used were determined based on modifications of the Technical Guidelines for Evaluation of the Effectiveness of Management of Marine, Coastal and Small Islands Conservation Areas (E-KP3K) and Sambah *et al.* (2020).

The eligibility category was determined based on the results of the assessment of the weight x score. Categorization was divided based on vulnerable classes which were divided into 3 categories. Classification of vulnerable feasibility classes was determined based on a maximum Si value = 42, Very feasible value ≥ 34, Eligible = 24-33, and a score of < 23 for ineligible criteria.

Gap analysis

Gap analysis is a method for identifying ecological temporal gaps in MPA. Spatial data are needed as a strength to identify disturbances or problems causing ecosystem degradation, for example due to mining, infrastructure, recreation and other activities (Jennings, 2000). This approach is intended to work in tandem with conservation targets focused on protective action for endangered species. Jennings (2000) describes the concept of gap identification as the process of identifying various elements of biodiversity and examining existing protected areas.

The gap analysis determines which elements (e.g., which habitats and species) are not represented in existing conservation areas. Scott *et al.* (1993) stated that gap analysis identifies representatives of biodiversity in areas managed exclusively for the maintenance of populations, native species and natural ecosystems. Comparison of the proportions that are protected and identified is one way to

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identify gaps in the process of protecting and conserving areas.

Gap analysis is usually applied to a fairly large area. Gap analysis is used for making decisions about conservation by considering data and information based on ecological boundaries to ensure that biodiversity is maintained (Dudley & Parish, 2006). The use of gap analysis can assist in determining the level of protection of conservation targets. Gap analysis can be used as a way of setting priorities for conservation action measures (Jennings, 2000).

Results

Area feasibility

Aquatic Tourism Park (ATP) of ecological condition of the Southeast Sulawesi Province ecological feasibility analysis is carried out so that the chosen conservation area is in accordance with its characteristics and also protect endangered species, habitats, and ecological functions (Agardy, 2000).

The ecological feasibility analysis is interesting to define MPA sustainability to conserve ecosystem and its protected fish. Based on the weighted and scored assessment, the feasibility analysis obtained a value of 31, which means that the area is included in the feasible category as shown in detail in Table 3.

Table 3 Results of the ecological feasibility matrix assessment.

No.	Criteria	Weight	Score	Value	Result
1	Endangered/protected fish species	4	3	12	5 species
2	Mangrove density	3	3	9	1703
3	Seagrass coverage	3	1	3	47.94
4	Coral reef coverage	3	2	6	45.74
5	Naturalness	1	1	1	± 27,5%
	Total			31	Feasible

Mangrove ecosystem

There are several research locations occupied by mangrove ecosystems, consisting of several mangrove species, such as *Sonneratia alba, Rhizophora apiculata, Rhizophora mucronata, Bruguiera sexangula*, and *Bruguiera gymnorrhiza*. The highest mangrove species variation was found at the observation station in Ranoha Raya Village and Mata Air Emba (4 species). This study showed that *R. mucronata* was the mangrove species found in all observation stations, while other mangrove species were not evenly distributed in all observation stations. *S. alba* can only be found at observation stations in Labutaone, Tambeanga and Ranoha Raya Villages. Meanwhile, *B. gymnorrhiza* was found in Tambeanga Village, Woruworu, Mata Air Emba, Tambolosu and Ranoha Raya.

The distribution and area of mangroves species were identified at four sampling stations during the study and three additional stations during the 2018 DKP survey, showing a total of seven mangrove sampling locations with varying densities and types.

The highest mangrove density was found at observation station 7 located in Ranoha Raya Village with a mangrove density of 2,345 shoots/ha. The lowest mangrove density was observed in observation station Labutaone Village with 900 stands/ha.

The average density of mangroves from the 7 stations was 1,703 stands/ha, which is within the good category, according to Decree of the Minister of Marine Affairs and Fisheries No 201-year 2004. Mangrove density value of ≥ 1,500 falls in the good category. The mangrove ecosystem distribution area in Southeast Sulawesi MPA can be seen in Figure 2.

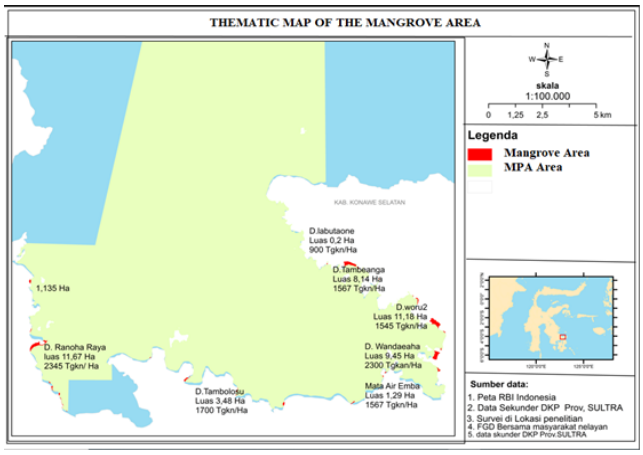

Figure 2 Thematic map of the mangrove area in Southeast Sulawesi MPA

Coral reef ecosystem

Coral reef coverage in the study site were varied with ecosystems scattered in several locations. There were 16 points sampling stations of coral reef coverage observed. Coral reef ecosystem coverage ranged from 9 - 78.3%. The average coral coverage at the study site was 45.74%, indicating that the existing coral reef was of moderate quality.

The decree of the Minister of Marine Affairs and Fisheries No 4-year 2001 states that coral reef coverage should be in the range of 25 - 49.9% to be considered in the medium category. Details regarding the distribution Coral reef in MPA Area can be seen in Figure 3

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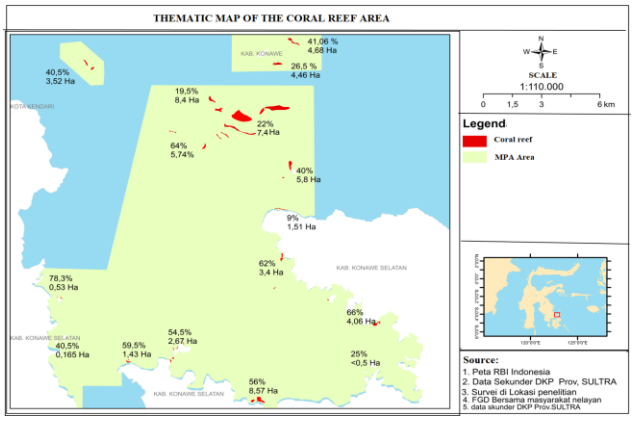

Figure 3 Thematic map of the distribution coral reef in MPA area

Seagrass beds

Seagrass beds are one of three important ecosystems in coastal areas, apart from coral reefs and mangroves. Seagrass ecosystems have an important role in supporting the life of various types of living organisms. Seagrass provides shelter for various organisms, as well as a breeding and foraging grounds for various herbivores fish and reef fish (Sjafrie *et al*., 2018). Seagrass also has the function of trapping and stabilizing sediments at the bottom of the waters, so that the water can become clearer.

The locations of seagrass distribution are scattered in the waters of the conservation area (Figure 4). The area of seagrass beds is different among areas. The highest seagrass coverage was found in Kendari Waters at station 1 which was 76.6%. Water condition in the waters of Pasi Jambe was clear enough so that the quality of seagrass coverage was good. Seagrass coverage around Lara Island, Wawosunggu Island and on the coast of Wawosunggu was low.

The low seagrass coverage in the Wawosunggu area could be due to industrial activities as well as the loading and unloading ports around the area. Seagrass coverage in Wawosunggu were 28% for the coast of Wawosunggu and 24.31% for Wawosunggu Island, which fell into damaged/poor category. Around the waters of Lapuko Bay, adjacent to Wawosunggu waters, there is a cement company having a loading and unloading pier which triggered the cutting out a lot of mangrove trees. Seagrass coverage nearby Lara Island was 31% which included in the unhealthy category.

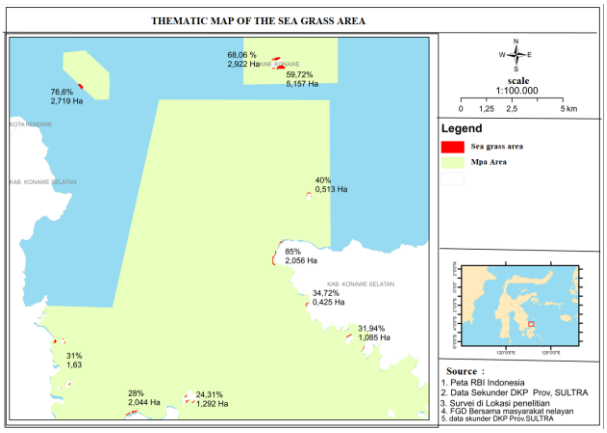

Figure 4 Thematic map of the distribution seagrass in MPA area

Protected fish

There are several protected fishes observed in the study area, such as Napoleon Fish (*Cheilinus undulatus*), Sea Bamboo (*Isis* spp.) and Giant Clams (*Tridacna* sp.), which most of them live in the coral reef ecosystem. Napoleon fish is currently under protection based on Decree of the Minister of Marine Affairs and Fisheries No 37-year 2013 with limited utilization status of a certain size.

Since 2004 Napoleon fish is included in the CITES protection under the Appendix II category. Sea bamboo is currently included in full protection through decree of the Minister of Marine Affairs and Fisheries No 8-year 2020. Giant Clam is also a protected biota based on Government Regulation Number 7 of 1999 concerning the preservation of plant and animal species due to their rare, endangered and having slow growth status. Giant Clam is also included in the Appendix II of CITES.

The designed conservation area is also expected to protect spawning areas of fisheries and marine organisms. The backup location contains areas suspected of being spawning grounds. This is indicated by the frequent finding and utilization of lobster seeds.

Naturalness

Naturalness is an indicator that looks at activities that occur in ecosystems in conservation areas. The authenticity indicator will look at the extent of the pristine area of the ecosystem contained in the conservation area. The results of intervening ecosystems are obtained from several data. The data obtained were in the form of the location of the fishing area, the location for collecting mangrove wood as a house material and the location for cultivation.

The collection process by showing a map of the location of the conservation area, so that fishermen/community will show the location of the area where they usually catch fish. Referring to giving active roles to local community groups when requesting information regarding the geographical information of their area (Chambers, 2006).

Tabel 4 Ecosystem area and active ecosystem

Ecosystem Criteria	Area (ha)	Active Ecosystem
Mangrove	46,545	Cage cultivation (KJA/KJT)
Seagrass	19,843	Fishing grounds
Coral reef	62,835	Ship shipping lanes
		Fishing boat mooring Collection of firewood and buildings
Total	129,223	93,687 ha

Source: Perda No. 9, 2018

The results obtained were 129,223 areas of mangrove, seagrass and coral reef ecosystems (Table 4). Existing activities in the conservation area that affect authenticity are in the form of cage cultivation activities, fishing grounds, ship shipping lanes, fishing boat mooring locations and the collection of firewood and buildings in the mangrove ecosystem of 93,687 ha of activity can be seen in table 4. So that the results of calculating authenticity ±27.5% or below or <50, which shows that it is not feasible so that in table 3 it obtains a calculation value of 1.

Gaps in the area conditions

Results of gap analysis indicated that ecological condition decreased in quality due to pressures from anthropogenic activities in the area. Bio-geographical information is needed to support the determination of spatial aspects, when activity increases and ecosystem degradation occurs (Jennings, 2000).

The results of the data from the pre-reservation conditions in 2012 showed that the quality of mangrove, seagrass and coral reef ecosystems had decreased. In addition to protected biota ecosystems, there is also a threat of habitat loss. Ecological gap analysis is used to ascertain whether the protected areas are ecologically healthy and have long-term survival (Dudley & Parish, 2006).

The temporal assessment is based on pre-reserve secondary data and post-reserve primary data to see how much the ecosystem quality has decreased, to provide additional information related to the management plan and zoning determination of the Southeast Sulawesi MPA. Determination of zoning and determination of appropriate area management strategies are expected to restore conditions and maintain the sustainability of the existing ecosystems.

There was gap state of coral reef, mangrove, seagrass in ATP. This study found that the degradation of coral reef around 10%, from 56.61% to 46%. This condition was also occurred on seagrass ecosystem as well, it was degradation from 65.45% to 48%. The condition of seagrass beds decreased by around 7%.

Mangrove density in the pre-reservation data was 1,805 shoots/ha, while the mean of mangrove density from observations at the location was to 1,703 shoots/ha, indicating the decrease of mangrove density in the study area. Coverage conditions of seagrass beds, coral reef, and mangrove density in the study area from 2012 to 2020 showed degradation (Figure 5).

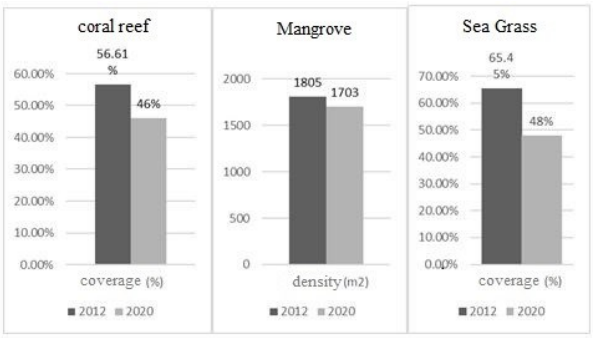

Figure 5 The gaps in quality decline of coral reef, mangrove and seagrass ecosystems

The same number of protected species were found in the study sites, showing 5 important and protected species, i.e., giant clams, turtles, dolphins, sea bamboos, and napoleons. The results of the three FGDs and field surveys found it increasingly difficult to find these species.

This indicates that the condition of the reserve area must be immediately developed and designated as a conservation area by taking into account the ecological aspects in the conservation area.

According to community support, the 71% (45 respondents) provided answers, i.e., 32 respondents answered agree, 7 disagree and 6 were undecided. Data from the reserve report provided a community support value of 95%. This means community support decreased over time due to insufficient socialization of the questionnaires to the surrounding communities. The detail of responded answers as can be seen in Table 5.

Table 5 Matrix of gap analysis result

Parameter	Ideal condition for conservation area	Pre-reservation condition	The latest condition
Coral reef coverage	> 50 %	56.61%	46%
Mangrove density	≥ 1,000	1,805	1,703
Seagrass coverage	≥ 60%	65.45%	48%
Protected biota	≥ 2	5	5
Community support	75%	95%	71%

Source: Data analysis, 2019

Discussion

The ATP of the Southeast Sulawesi was suitable for MPA management, based on the analyzes feasibility which shows a feasible status. The highest value supporting the ATP was protected fish species (12), followed by mangrove density, seagrass coverage, coral reef coverage, naturalness. Dudley & Parish (2006) suggested that the most interesting consideration on why we need to define a certain MPA is the protected fish.

Conservation area must support the maintenance of ecosystem functions, as well as prioritize the habitat needed by endangered species and have high ecological value (Walton, 2014). Conservation areas that are designed by mapping and containing detailed information are expected to be able to protect various ecology systems and can provide economic and social benefits (Metcalfe *et al.,* 2015).

The ATP feasibility was also need to be considered by other important factors. Results of this study indicated that conservation areas have a fairly high representation of important habitats and protected species. The assessment serves as the basis for future actions and decision-making in large areas of conservation areas (Knigth *et al*., 2006).

Assessment can provide input on the excess activity of a conservation area that has considerable potential. Identification step is important to be implemented in each area planning in terms of area, condition and diversity, to provide appropriate management and handling information on protected features (Smith *et al*., 2009).

It is imperative to have knowledge on the limits of the conservation area in supporting activities in the area, not only in terms of habitat and species representation, but also in providing sustainable benefits. However, these ATP is needed to concern on ecosystem state.

This research found that density decreasing of mangrove ecosystem from the period between 2012 to 2020. It might be caused by mangrove area conversion, mangrove utilization and degradation due to other anthropogenic factors. As known that mangrove ecosystem is an ecotone area connecting land and sea, having an important role as a life support area (Wardhani, 2014) and high vulnerability.

Indeed, mangrove ecosystem has function as spawning, nursery, feeding ground area (Wardhani, 2014). It is important to consider all information related to the existence of mangrove ecosystems as one of the conservation target criteria in the management of conservation areas.

The decreasing state of ecosystem was also observed on coral reef ecosystem. It might be mostly caused by destructive fishing practices. These factors were also observed on coral reef ecosystem within all other MPAs in Indonesia (Edinger *et all.* 1998).

There were two locations having low coverage values on coral reef coverage, namely around the waters of Tanjung Gomo and Sapa Hari Island. Coral reef coverage less than 24.9% falls in the bad category of coral coverage according to the Decree of the Minister of Marine Affairs and Fisheries No 4-year 2001. The situation is in line with the statement of Edinger et al. (1998), who stated that the damage to coral reefs in the Indonesian seas is mainly caused by over-exploitation, pollution, ship anchors, epidemics, destructive fishing practices and due to siltation.

In Sapa Hari Island where intensively used as fishing area, destructive fishing activities were observed during the survey. The use of fish bombings that caused damages to coral reefs is among the main destructive fishing practices in this area. Sapa Hari Island is a shallow sea area with a wide expanse of coral reefs, so it is preferred by fishermen to conduct fishing activities.

Some fishermen still use fishing bombs to catch fish, causing the decrease and damages of coral reef coverage. The main cause of this quality decline is the use of fish bombs by fishermen for catching fish, which lead to the damage of coral reef ecosystem. Other type of reef destruction is caused by fishing nets get snagged in coral reef, which causes direct destruction on coral reef.

The lowest coral reef coverage was observed in the waters of Tanjung Gomo. The initial identification of damage suggested that the damages could be caused by very strong water currents which hindered the restoration of coral reef coverage. Coral reefs are very sensitive to disturbance. The slightest change in the coral reef environment can destroy an entire coral reef colony. The existence of coral reefs depends on environmental conditions that changes according to space and time because sea conditions

continue to changes dynamically (Madduppa *et al.*, 2016).

This research also found that there has been significant decreased in seagrass ecosystem. There were several landfill mining companies in Lara Island, which might lead to increasing sedimentation where affects the live of seagrass beds. In the study area, the decline in seagrass quality is mostly due to anthropogenic activities such as massive dredging and stockpiling activities. Disposal of salt waste due to desalination processes, waste from industrial activities, and hot water waste from power plants provide huge impact on seagrass ecosystems (Sjafrie *et al.,* 2018).

In general, the average condition of seagrass coverage in the Southeast Sulawesi MPAs is not healthy, with seagrass coverage value of 47.94% Decree of the Minister of Marine Affairs and Fisheries No 200-year 2004 states that coverage value of 30 - 59.9% falls in the unhealthy category. Seagrass ecosystem is one of the ecosystems that must be conserved. Seagrass conservation aims to maintain the ecological and economic services of seagrass beds that are scattered in the Southeast Sulawesi MPA. Seagrass beds function as protection and preservation of fish species and provider for fisheries productivity (Ambo *et al*., 2013).

Damages in seagrass ecosystems was also caused by sedimentation due to sand mining activities on the coast and the use of fishing bombs leading to heavy sedimentation covering the seagrass surface. Activities at the wharf tend to reduce the quality of seagrass.

Local community settlements also tend to be above the water level, which disturb the seagrass beds. Coastal development, sedimentation, mining activities, excessive exploitation of fish associated with seagrass and physical activities, such as ports, are generally the causes seagrass ecosystems decline in Indonesia (Unsworth *et al.,* 2018).

Effects of settlements development in the study area is not significantly observed since residential settlements tend to be traditional and not densely populated. Mangrove cutting is also observed for construction of local houses and firewood done by the local community.

The decreasing quality of ecosystems have an impact on ecological processes of mangrove, coral reef and seagrass ecosystem. It can be caused to the level of area protection to be inappropriate (Dudley & Parish, 2006). The decline is a gap that occurs in the region. The gap analysis identified that elements of biodiversity should be sufficiently protected in the area, so that it can be considered in management (Jennings, 2000). According to the statement, this research suggested to formulate rehabilitation and management strategy to recover mangrove, coral reef and seagrass ecosystem.

The decline status of mangrove, coral reef and seagrass ecosystem is also supported by perception gap analysis which was conducted with in fishing community. In obtaining opinions on the social aspects, research questionnaires were distributed to the surrounding communities.

About 71 % of the questionnaires were obtained from the communities and they agreed that declining state of those ecosystem was observed (Table 3). MPA might support to increase health of mangrove, seagrass and coral reef ecosystem as an indicator of ecology. It can cause the fish enrichment and spill over to use zone this MCA. Finally, an appropriate fish stock can also support capture fisheries livelihood. Intention of MPA and sustainable livelihood have an important role in fish management.

This gap analysis is also implemented to assist the design of conservation area management. The gaps that occur in the conservation area can later lead to non-representation of species and even the entire ecosystems in the area (Dudley & Parish, 2006).

The results of the gap analysis will be taken into consideration in the feasibility analysis and determination of conservation targets in the management of conservation areas. The discovery of gaps in the area can be important information in area management.

Finally, it can be concluded that the conservation areas are needed not only to protect biodiversity, but also to provide support on sustainable fisheries management and marine economic development. This area development is carried out through a series of planning, implementation, monitoring and evaluation stages. Improvement on MPA management effectiveness is also needed, by implementing a more comprehensive and inclusiveness of all involved stakeholders of the MPAs in the area.

Conclusion

This study tried to find several gap states of mangrove, seagrass, and coral reef ecosystem; and MPA feasibility to design and good practice management of Southeast Sulawesi marine conservation area from the concept to implementation base on scientific analysis. It can also support fisheries management system to develop capture fisheries livelihood for fishing management in Southeast Sulawesi. This study indicates that the

feasibility analysis showed results of proper status for the study area to become conservation area, with scoring of 31.

The criteria used in the assessment were selected based on contribution in maintaining important ecological processes and as an ecosystem buffer system in the area. According to this conclusion it can be recommended that the Government of Southeast Sulawesi Province are implementing appropriate management based on surrounding environmental and community aspects and rehabilitating seagrass beds, coral reefs and mangrove densities. Further management actions are needed to be implemented in securing the process of conservation which can be used as source of ecosystem services of the area.

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How to cite this paper:
Imran, Z., C. Wijayanto, F. Yulianda. 2023. Evaluation feasibility and ecological gap in marine conservation area of Southeast Sulawesi Province. Depik Jurnal Ilmu-Ilmu Perairan, Pesisir dan Perikanan, 12(1): 87-98.