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Mangrove Ecosystem Management based on Mitigation for Natural Disaster in Coastal Community

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***Abstract*— Mangrove trees plantation program is expected to restore a damaged environment. The purpose of this research was to: (1) identify the part of mangrove that serves as disaster mitigation (2) analyze the function of mangrove physical ecosystem in preventing a natural disaster, and (3) analyze economic value of mangrove ecosystem in overcoming natural disaster for the coastal community. The method used in this research are creating the transect the location of observation and analyzing the economic valuation. The results of this study are as follows: (1) roots, stems, branches and twigs that make form a unity as mitigation of coastal natural disaster and small island, (2) mangrove roots consists of various types and cross-shapes vertically and horizontally , other than that the roots, stems, branches, and twigs of mangrove vegetation strong and elastic so it is not easily broken or cut, and (3) the value of mangrove valuation from physical function to overcome natural disasters is about IDR. 6, 075, 892, 844. The suggestion in rehabilitation effort or recovery of mangrove ecosystem should be done semi-natural. Let human only spread the seeds of various types of mangrove on the expanse to be restored its ecosystem as well as let distance and line grow naturally. Rehabilitation result of mangrove ecosystem is expected to reach high diversity level and adaptive to the environment. In addition. let every mangrove seeds grow naturally ensuing the ecological condition.**

***Keywords*— mangrove vegetation; mangrove ecosystem; disaster mitigation; economic value; whirlwind; sea water waves.**

I. INTRODUCTION

Sinjai regency is one of the coastal districts in South Sulawesi Province which has 31 km coastline with 17 km inland and 14 km on islands spread over nine small islands [1]. Sinjai Regency geographically facing directly to the waters of Bone bay that facing east so susceptible to the sea action in the dry season in the form of a whirlwind, big waves, salt water interaction and other sea disasters that at any time threaten the coastal district of Sinjai.

Throughout the 17 km, the coastal coastline of Sinjai District that extends from north to south in the 1970s to 1980s is very barren mangrove ecosystem is almost extinct due to converted into pond land and other designations. One of the coastal villages that became the research site is Tongke-Tongke Village which has 2.5 km of coastline. According to some informants who told the researchers that in the 1970 to 1980 era the inhabitant's village nearly 80%displaced their homes to the mainland because of the sea action from year to year increasingly vigorous main windstorm and sea waves.

As a result of the sea action, the Tongke-Tongke Village populations house at the top of any time during the dry season is threatened by the whirlwind, as well the action of sea waves that threaten the building of the house at the bottom, the informant adds that sometimes some of the house poles have been lost at the end down due to abrasion caused to the frequency of sea waves both in quantity and quality increasing from year to year due to the loss of green lane. Not only the whirlwind and sea waves are complained of coastal inhabitants, especially Tongke-Tongke village but also increasing salty water intrusion to the land that causing wells Samit of population increase, so that all the water need of population purchased from other regions.

As a solution to overcome this condition, in the mid of 1980s people started to plant mangrove trees preceding the action of mangrove trees planting program nationally. The existence of mangrove ecosystem is the result of the strong struggle. Restoring a damaged environment requires sacrificing time, energy, and mind thought are not as easy as turning a palm.

The coastline along Sinjai regency 17 km which extends from north to south as a tidal area with potential aquaculture land is 1,600.46 which is currently managed around 716.50 ha [2]. In addition, there are mangrove ecosystems of 1,351.50 ha spread over nine coastal villages. The area of mangrove ecosystem owned by Sinjai Regency is 350.50 ha or 25.90% located in Tongke-Tongke Village which is the research location to study ecological function of mangrove ecosystem physically.The purposes of this research are: (1) to identify mangrove part that serves as disaster mitigation (2) to analyze the ecological function of mangrove ecosystem physically in preventing a natural disaster, and (3) to analyze economic valuation value of mangrove ecosystem in overcoming natural disaster for the coastal community.

II. Materials and Method

A. Time Location

This research was conducted for five months starting from January to May 2018, while research location isTongke-Tongke Village, East Sinjai District, Sinjai Regency, South Sulawesi Indonesia as presented in Figure 1.

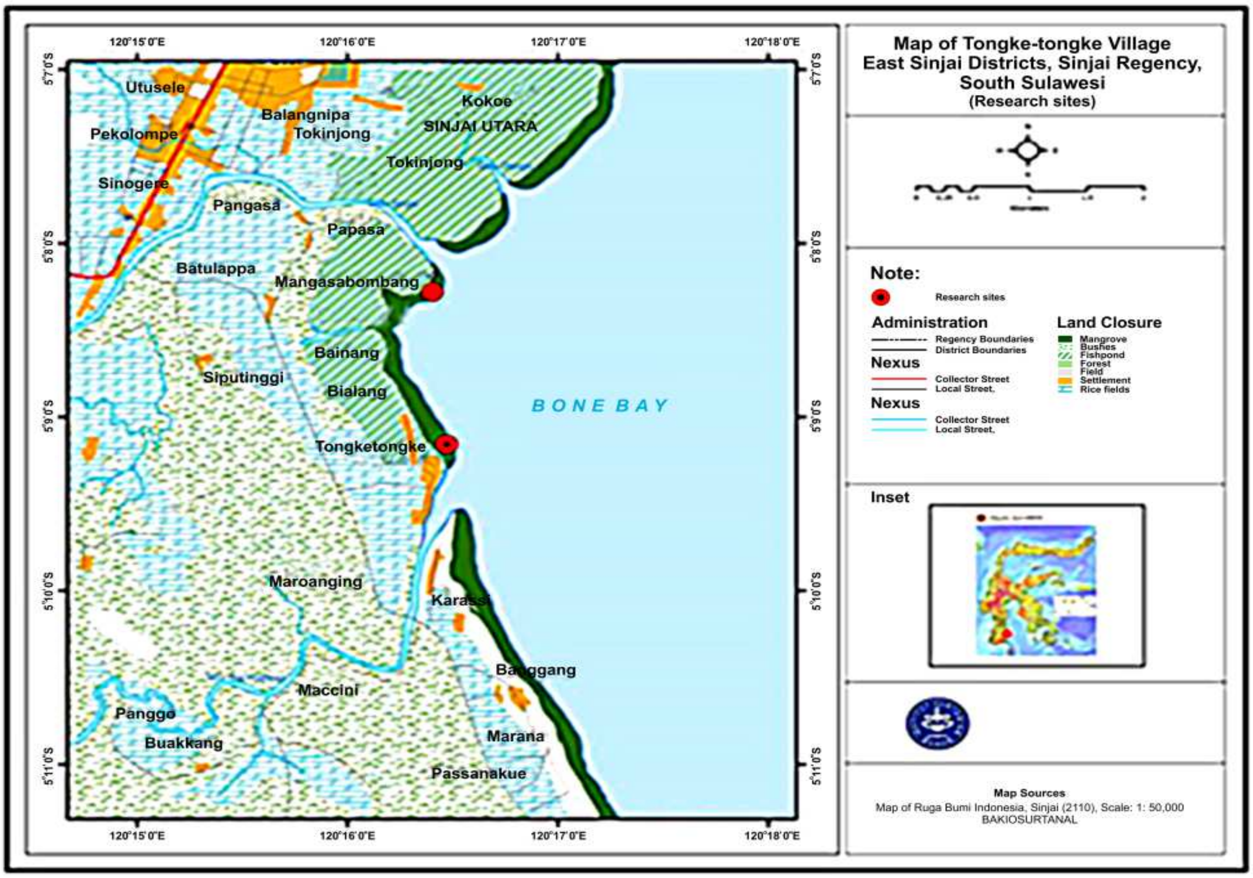

Fig. 1. Map of research sites of tongke-tongke village, east Sinjai district, Sinjai Regency

B. Tools and Materials

The tools and materials used in this research are writing station, roller meter to make transect observation station,rope, ruler, a compass to determine transect direction, engineering book of mangrove ecosystem management as a support in identifying mangrove vegetation types and parts that include roots, stems, stalk, twigs. The four parts of this mangrove vegetation will be a description in writing that examines the ecological benefits of mangrove ecosystems physically in overcoming natural disasters in coastal communities.

C. Research Procedure

Before conducting this research, there are several stages: (1) determination of research location. Tongke-Tongke village is designated as a research location because the characteristic of this village is considered to represent the coastal village in Sinjai Regency (2) determining the transect as an observation station, and (3) determining the direction of the transect line and layout.

D. Research Design.

In order to get a characteristic representative of mangrove ecosystems in coastal waters of Tongke-Tongke Village made four transects as observation stations measuring 10 X 10 square meters. This transect is made perpendicularly from the direction of the coastal plain to the sea, the layout of the four square-shaped transects in the four directions of the wind. In this transect, observations of mangrove vegetation characteristics were observed: vegetation type, mangrove vegetation density, the average height of mangrove trees, the average diameter of mangrove stems, root shape of each mangrove vegetation types.

E. Data Analysis.

Data analysis used in this research are: (1) data analyzed include: mangrove vegetation type, mangrove vegetation density, height of the tree, diameter of tree, average and type and root form of each type of mangrove vegetation, and (2) data are analyzed quantitatively which describes qualitative to the data that has been processed.

III. Results and Discussion

A. General Location Overview

Administratively TongkeTongke Village is one of the coastal villages in East Sinjai District and it is the result of the expansion of Samataring Village in 2003. TongkeTongke Village is administratively divided into five hamlets as follows: (1) Cempae, (2) Barana, (3) Maroangin, (4) Baccara, and (5) Bentenge.

Geographically TongkeTongke village is adjacent to the north with Samataring Village, to the east with Bone Bay waters, the south withPanaikang Village, and to the west with Batulappa Village. TongkeTongke village has a coastline of approximately 2.5 km extending from north to south, with a total area of 4.75 km2 or 475 ha. The Tongke-Tongke village bordering on the waters of-of Bone Bay is prone to natural disasters especially the whirlwind, and sea waves and other sea action.

The demographic population of TongkeTongke Village according to East Sinjai District data in 2016 figures as follows: 3.279 people with the percentage of men 1,514 people or (46.17%), and women 1.765 people or (53.83%). Generally,TongkeTongke Village residents are Bugis tribe with the everyday language used is Bugis language.

Residents of TongkeTongke village, amounting to 3,279 inhabitants, 448 people who work as pond farmers and fishermen with details of 103 people as fishpond farmers and 385 people as fishermen. The characteristics of fishpond farmers and fishermen as follows: (1) the average age is 26 years old to 60 years old, (2) the level of education; people who did not graduate from elementary school is 15.62%, graduated from primary school is 39.06%, graduated junior high school is 31.47%, graduated high school is 10.50% and 3.35% is fresh graduate, and (3) average income between IDR.750, 000, - to IDR.2, 000, 000, - per month.

B. Characteristics of Mangrove Vegetation.

Characteristics of mangrove vegetation in this study include (1) mangrove vegetation type, (2) mangrove vegetation density, (3) average tree height, (4) average tree diameter, and (5) type and shape root. Generally, the forms of mangrove root of each species are formed horizontally and vertically, thus crossed-cross mutually reinforcing each other to portray ecological functions to prevent coastal abrasion, trap sediments and pollutants, prevent saltwater interactions on land [3].

1) Type of Mangrove Vegetaion: The results of the study (Sambu and Sribianti, 2016) types of species mangrove vegetation found in the Tongke-Tongke mangrove ecosystem are four types: (1) Rhizophora with a dominant level of 91.50%, (2) Bruguera with a large degree of dominance of 4.50% (3) Avicennia with the dominant level of 2.40% and (4) senneratia with the dominant level of 1.60%. The results of this study indicate mangrove ecosystems Tongke-Tongke Village has a low level of biodiversity because only dominated by one type of Rhizophora which reached 91.50%, it indicates that the mangrove ecosystem is in a state of unstable.

One source mentions that the deficiency of recovery result of mangrove ecosystem recovery done by people is generally dominated by one of the species. Each species in an ecosystem has its own function in running an energy cycle, and for certain species cannot be replaced by other species, the higher level of biodiversity of an ecosystem the healthier and more stable an ecosystem. Thus, the importance of biodiversity in Indonesia was born Law No. 5 of 1990 on the preservation of biodiversity with its ecosystem [4]. The statement above is in accordance with the recommendation of Mangrove Action Project which abbreviated as MAP, mangrove rehabilitation system should be done by not planting directly, but rather spread some types of mangrove fruit in the area that will be rehabilitated and let it grow naturally, so that each type of mangrove will grow according to their habitat [5]–[8]. With such rehabilitation models, it is expected to grow several types of mangrove vegetation and occupy their habitats naturally.

2) The Density of Mangrove Vegetation: Result of density analysis mangrove ecosystem done in Tongke-Tongke village, is 11,750 individual ha^{-1} is almost same with result of Asbar analysis found density of mangrove vegetation 12.000 individual ha^{-1} [9], there are differences from both result of the study above, this happens because it has been found dead of mangrove vegetation every year is estimated between 2-3 individuals each transect with an area of 100 m2, if it is converted to 30 individuals ha^{-1} the^{-1}. The difference in data indicates that in 10 mangrove vegetation deaths in Tongke-Tongke Village it was estimated between 250-300 individuals ha^{-1}.

The deaths of mangrove vegetation in the mangrove ecosystem of Tongke-Tongke are suspected of mangrove vegetation density that affects: (1) photosynthesis does not go perfectly, (2) the circulation of oxygen is relatively closed, and (3) the circulation of nutrients is limited, because the part of expanse is almost closed by new sapling of mangrove species, in addition to limited water circulation at high tide.

3) An average of Tree Height: The result of observation and analysis that the average of mangrove trees in Tongke-Tongke mangrove ecosystem reaches a height of 15-25 meter, this is high compared with other mangrove ecosystem existing in Sinjai Regency. It is allegedly too tightly so that it has no room to grow sideways but grows upward. Ecologically with such conditions, the existing mangrove ecosystem in Tongke-Tongke village is very effective to prevent whirlwind in the dry season, considering Tongke-Tongke Village Geographically facing directly with Bone Bay waters so vulnerable to the threat of waves and whirlwind.

In addition to the direct benefits of mangroves as coastal protection from the action of sea water waves and whirlwind, also as firewood has a large market prospect, call it the mangrove ecosystem management system in Matang Penang Malaysia. The mangrove ecosystem management model in Malaysia is bestowed for timber with rotary logging systems so that the ecological function of the mangrove ecosystem remains sustainable. One of mangrove forest management model in Matang Malaysia with silvicultural system is 40,466 ha with the following details: (1) production reserve area of 2,833 ha or 7%, (2) unproductive area of 405 ha or 1%, and (3) protected areas of 7.284% or 18%, and (4) production areas of 29,945 ha or 74%.

With silvicultural system cutting down with rotation for 30 years, so every year will be logged 998 ha with the selling price of RM. 30 million or equivalent IDR.7.8 billion or an average of IDR. 261 million ha-1 the-1, when compared with the result of sales price estimation analysis by cutting down mangrove forests in Sinjai Regency, South Sulawesi, Indonesia, which result is three times as much as IDR. 900 million ha-1, but the management system undertaken in Malaysia is more environmentally friendly because the cutting rotation system is around 30 years [10].

4) An average Tree Diameter: The results of measurement and analysis of mangrove vegetation diameter of Tongke-Tongke Village are relatively varied between 10-30 cm with the average age between 25-30 years, the size of the diameter is relatively slow when compared with the existing mangrove ecosystem in other areas. The slow growth of mangrove vegetation in Tongke-Tongke Village is too tight, so it is difficult to get good room for photosynthesis and get oxygen, and also limited to get nutrients caused by the stratification of vegetation in stages, new puppies, if there is no effort to reduce the soil surface gradually, will be covered by vegetation tillers.

Such condition if the mangrove ecosystem is intended only to solve natural disasters for coastal areas and small islands more effective, but it should be understood that the existence of mangrove ecosystems have varieties of ecological rather than physical functions, but it has other ecological functions such have as the habitat of various coastal organisms. In order for mangrove ecosystems can function as a habitat of various coastal organisms should be available space or expanse that flooded even if continuously in a state of the ebb. That is one of the positive mangrove ecosystems rehabilitated naturally by spreading the seeds on a rehabilitated stretch and allowed it to grow naturally without human involvement in setting rows and distances [5].

5) Kinds and Roots: Ecologically mangrove ecosystems are planting or vegetation communities that grow in tidal areas, zoning regularly from the lowest tide to enter the land area that still gets the effect of the tide. According to Dahuri (2003), 8 mangrove plants, in general, have root type of form that is: (1) root of the rod for vegetation type Rhizophora sp, (2) root of claw for the type of Avicennia and senneratia, (3) knee root for Bruguera type, 4) papa root for xilocarpus. One of types and shapes of mangrove root as presented in Figure 2.

Fig. 2: Type root of the rod of the Rhizophora

Figure 2 shows that the mangrove root is neatly arranged and crossed-cross and at all ends swooped into the soil, so it is strong to face the sea waves to prevent coastal abrasion, trapping, dissolving pollutants. In addition, there are gaps between roots as a shelter for various types of organisms from tallies birds and predatory of various types which have a large-sized organism.

The four types and root shapes have function optimally, ranging from predominant zonation dominated by Avicenna and sanitaria which have roots of claws, Bruguier that have knee roots, and *rhinophoral* that have stick roots have the ability to face the waves of seawater. In addition to mangrove root characteristics that cross each other, it also has a chewy nature is not easily broken and cut, despite being hit by a hard wave, is elastic to hold water waves all the time,

C. Value of Economic Valuation.

Ecosystems of mangroves have ecological functions that can be considered as economic valuations that can be subdivided into four, namely: (1) the value of direct benefits, (2) the value of indirect benefits, (3) the value of benefits of choice, and (4) the value-existence (Sambu, 2011)9. This study will only examine the direct benefit value of mangrove ecosystem physically from the root, stem, stalk, and twig that serves to prevent: (1) whirlwind, (2) sea waves, and (3) saltwater interaction to land.

1) Whirlwind: One of the natural disasters that often threatens coastal inhabitants is the whirlwind that occurs annually in a coastal area that destroys coastal inhabitants house and small islands and sometimes houses are flattened to the ground. So loudly the whirlwind of the hippopotamus that used to hit the coastal areas sometimes and small islands, so the parts of the house that right like roof and wall fly scattered, and that is what often hit the village community Tongke-Tongke before the existence mangrove ecosystem spread over 2.5 km coastline as a green line.

The result of physical direct benefit value from mangrove ecosystem to prevent whirlwind for Tongke-Tongke Village with a number of approximately 656 houses. If the value of an average house building IDR.350.000.000, - per item means direct physical benefit value of IDR 229.250.000.000, -. The result of this study (2017) ecosystem can be converted into economic valuation value of mangrove at Tongke – Tongke village which is IDR. 65.406.562 $ha^{-1.}$

2) SeaWater Waves. The economic valuation value of the mangrove ecosystem to prevent coastal abrasion will cause the shoreline changes to the land, which will affect the residential areas of the community, industrial area, tourism area, farm area, and other areas. One portrait of how the action of the ocean waves continuously erodes a building as shown in Figure 3.

Fig. 3 One of the sea wave action portraits in Buntusunggu Village, Takalar District, South Sulawesi, Indonesia

One portrait of the ocean waves as presented in Figure 3, shows how if this condition has no attempt to prevent either naturally or artificially. In order to make this effort, it is necessary to identify the suitability of coastal characteristics whether it is possible to prevent naturally occurring mangrove cultivation or to prevent artificial breakwater in various forms. For beaches that are ecologically unable to grow mangroves properly, they should be made to prevent abrasion made by a breakwater.

One source mentions that to build a wave breaker1 m^3 needed costs U $ 19,791 or equivalent to IDR. 265,614.3 [11]. So, to build a breakwater wave with a thickness of 3 m3 along the 2,500 m cost is required with the calculation as follows: IDR.265,614.3 X 9 X.2,500 m = IDR.5,976,321,800, -. The results of this study indicate that the economic valuation value of mangrove ecosystem of Tongke-Tongke Village with 351,50 ha is IDR.5,976,321,800, - from the root function to prevent coastal abrasion.

3) Infiltration of Salt Water: The economic valuation value of the mangrove ecosystem prevent the interaction of saltwater to the land which causes the wells of coastal communities to be salted so that they have to buy water for daily needs both for drinking and eating needs and for bathing cases or MCK. The results of the study [2] in Tongke-Tongke Village is about the integrity of drinking water and daily washing bath cases of approximately 100 liters per person, with details for drinking and eating needs of about 10 liters per day or 10% of total needs, while for water bath cases about 90 liters per day or 90% of total daily needs.

The results of this study, if analyzed ecological function of mangroves from roots as a saltwater biofilter to land with a mangrove ecosystem area of 350.50 ha that occupies 2.5 km of coastline that is 100 liters per day per person or IDR.10,000 per day, it means to spend IDR.3,650,000 , - per person the^{-1}, and if converted to the number of residents Tongke-Tongke village that is 3,279 ecological valuation of mangrove ecosystem from the root function of 11,968,356,000, - to obtain the ecological value of direct physical benefits of IDR.34,146,522, - ha^{-1} the$^{-1.}$

Result of water requirement analysis for Tongke-Tongke Village community with existence of ecosystem can be reduced by IDR. 10,771,520,400, - or 90% of the total requirement, because the water requirement for washing bath cases can be obtained from residents' wells that had high salinity, but with the mangrove ecosystem become brackish even in the rainy season becomes bargaining. Coastal community expenditure Tongke-Tongke Village only for drinking and eating needs is IDR.1,196,835,600, - or the remaining 10% of total needs.

The analysis of economic valuation value of mangrove ecosystem function from the physical function as mitigation of coastal natural disaster and small islands of IDR.6.1 billion ha^{-1} not including physical function as building material and firewood as well as the habitat of various coastal organisms. The results of this study, similar to the results of a study on the value of economic valuation mangrove 7.8 billion ha^{-1} [12].

IV. Conclusion

In conclusion, the results of the research are as follows: (1) Part of mangrove tree that function physically in disaster mitigation include: roots, stems, branches and twigs form a unity as mitigation of coastal and small island natural disasters, (2) mangrove root which consists of various types and shapes cross each other vertically and horizontally, in addition to the roots, stems, branches and twigs of strong and elastic mangrove trees so it is not easy to broken or cut to prevent whirlwind in protecting coastal settlements and small islands , and (3) mangrove valuation value from physical function is to overcome natural disasters in the form of sea water waves and whirlwind that is equal to IDR.6.1 Billion has not included other physical function such as firewood of IDR.1 billion not including its physical function as building material.

As a suggestion in the rehabilitation or restoration of mangrove ecosystem should be done semi-natural, humans only spread the seeds of various types of mangroves on the expanse that ecosystem will be restored, let the distance and line grow naturally. Rehabilitation result of mangrove ecosystem naturally the level of its diversity is higher and more adaptive, let the every mangrove seeds grow naturally according to ecological condition respectively.

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