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Mangrove Distribution and Its Imperative for a Collaborative Ecosystem Management Approach in Maluku

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Abstract

Mangrove forest contains a large amount of non-biodegradable organic materials. Therefore, the forest plays an important role in mitigating climate change by absorbing carbon and sequestrating greenhouse gases. Though this is beneficial to both humans and the ecosystem, the existence of mangrove habitats is increasingly threatened due to the indiscriminate utilization of unsustainable forests for development purposes. These include the production of building materials, firewood, and charcoal. The major factor which leads to this indiscriminate utilization is the lack of knowledge about the important roles of the forests. Consequently, it has become necessary to develop the concept of mangrove ecosystem management using an integrative and collaborative zoning approach. The aim of this study is to determine the condition of mangrove vegetation in West Seram Regency, and the appropriate approach to its management zoning policies. It was conducted using vegetation and spatial analysis, and the results showed that there were 13 species of mangroves. Due to this diversity and the threats to mangrove ecosystems, management policies which integrates the ecological, social and economic aspects of the ecosystems need to be developed. Furthermore, these policies should divide mangroves into protection and utilization zones. In conclusion, the coordination and development of a collaborative management approach is very essential to the sustainability mangrove ecosystems.

Keywords: Mangrove forests, zoning approach, the collaborative ecosystem management sustainability

INTRODUCTION

Mangrove forest ecosystems provide various ecological, social, economic and protection functions. However, they are currently being utilized for other purposes globally. There is a belief that this ecosystem needs to be protected because of the numerous sea fishes and shrimp species that directly forage and interact therein (Farley *et al.*, 2009). [1]

Generally, mangrove forests are located in strategic coastal areas and are commonly at the center various development activities. Nevertheless, more than half of these forests have been damaged due to various factors such as the conversion of mangroves for other uses, expansion of urban areas/urbanization, pollution of coastal areas by waste material, and the lack of public awareness on the roles the forests play as a buffer for land and marine life (Murdiyanto, 2003) [2].

Mangrove ecosystems interact with a variety of community activities, especially those of coastal communities that depend on the ecosystems as a source of livelihood (Pattimahu *et al*, 2010) [3]. Consequently, there is an increasing threat to the existence of the ecosystems which are located adjacent to residential communities, due to the increase in the rate by which they are used for various activities. These include urban expansion, overfishing, extraction of wood for fuel and other uses. Therefore, this study examined the dynamic changes of the ecosystem due to multiple factors including coastal residential expansion and community pressures in Maluku, especially in West Seram Regency.

King (2000) [4]stated that mangrove ecosystems are not sustainable, thus are going extinct . The condition affects marine organisms such as fish, shrimps, and crabs which are very dependent on the ecosystems. Problems which lead to the above condition, that are yet to be resolved are the state of the Bioecology of mangroves, socio-economic characteristics of communities living around the forests, felling of the mangrove trees arbitrarily by some communities, and the conversion of mangrove lands for other purposes.

Due to the importance of mangrove forests to the sustainability of the ecosystem, it is necessary to formulate a policy for the sustainable management of the mangrove ecosystem-based approach to zoning. This is because, the policy can help in maintaining and preserving the functions and benefits of a sustainable mangrove ecosystem.

The purposes of this study were to 1), determine the condition of mangrove vegetation in Taman Jaya, West Seram Regency, Maluku and 2), Ascertain the appropriate approach to mangrove management zoning policies.

EXPERIMENTAL

Materials

The tools used include GPS, rollers, rafts, stakes, scissors, cameras digital, plastic bags, labels, tissue, stationery and mangrove identification book.

Methods

This study was conducted in Taman Jaya, West Seram, Maluku from March to July 2016, using a survey method. Furthermore, this method was carried out through systematic sampling techniques, using a combination of path and striped method. The data were in the form of primary and secondary data, and were the general conditions of the location and other supporting data related to the study. Furthermore the variables included: a. Composition, diversity, and richness of mangrove species, and b. Mangrove zoning.

The data were analyzed using vegetation analysis to investigate the diversity of mangrove species found in Taman Jaya. In addition, the analysis was conducted by calculating the species composition data including, the species density, relative density, dominant species, type closure, relative closure, and important value index. In accordance with Ludwig and Reynolds, 1988, the diversity of mangrove species was obtained using the Species Diversity Index formula of Shannon and Weaner [5]

Namely:

$$H = \sum 1 = I\ pi \log pi$$

Note:

H = Index of Species Diversity

Pi = n / N

Description :

n = The importance of a type

N = Total importance of all types

Finally the data were analyzed using Spatial Analysis to determine the zoning with regards to mangrove management in Taman Jaya.

RESULTS AND DISCUSSION

Mangrove vegetation conditions

Rhizophora spp, *Avicenia* spp and *Sonneratia* spp were dominantly found in the mangrove forests, and belonged to the category of major/true mangroves. Furthermore, they, dominated all growth levels, namely tree, sapling and seedling levels. Mangrove forest is an ecosystem which can be divided into major/true, minor and associated mangroves (associated). The major/true mangroves can only survive in mangrove forest environments, have special adaptive features, such as breath roots, and can thrive in salty environments. Moreover, minor mangroves do not play a role in the mangrove community, while mangrove associations/follow-up usually grow in the midst of land plants. Families that belong to true mangroves according to Noor et al (2006) [6] are *Avicenniaceae, Rhizophoraceae, Bombacaceae, Euphorbiaceae, Arecaceae, Myrtaceae, Lythraceae, Rubiaceae, Sonneratiaceae.* Meanwhile, those that belong to minor mangrove and follow-up includes *Meliaceae, Pelliciera, Lecythidaceae, Guttiferae, Apocynaceae, Verbenaceae, Leguminosae, Malvaceae, and Convolvula* .

The main mangrove species that are often found include Avi*cennia* sp., *Rhizophora* sp., *Bruguierra* sp, and *Sonneratia* sp. Furthermore, these species, including all others are related to their environment, with regards to the place they grow, tides, salinity, physiography, river conditions and human activities. According to Kusmana, *et al*, 2003 [7] mangrove species, especially those belonging to the genus *Rhizophora, Bruguiera, Sonneratia, Heritiera* and *Nypah* grow in ecological conditions related to the level of water salinity and soil conditions, and inundation regimes capable of forming distinctive zones.

The mangrove ecosystem in Taman Jaya of West Seram Regency consisted of 13 species, namely: *Rhizophora stylosa, Rhizophora apiculata, Rhizophora mucronata, Bruguierra gymnorrhiza, Ceriops tagal, Avicennia officinalis, Avicennia lanata, Avicennia alba, Xylocarpus moluccensis, Soneratia alba, Scyphiphora hydrophylaceae, Heritiera littoralis, and Lumnitzera racemosa.* Furthermore, the species had a tree, sapling, and seedling density of 60 ind/ha, 3923 ind/ha, and 29,047 ind/ha respectively. *Ceriops tagal* was found dominating the forest area and had the highest tree density of 13 ind/ha. Meanwhile, *Lumnitzera racemosa* had the lowest at 2 ind/ha. *Rhizophora apiculata* had the highest sapling density level of 1057 ind/ha, while the lowest was *Lumnitzera racemosa* with 9 ind/ha. Finally, as for seedling category, *Avicennia lanata* had the highest density level of 5684 ind/ha while the lowest density was at 29 ind/ha.

Table 1. Mangrove Trees Species Density and Diversity

Number	Species	Relative Density	Relative Frequency	Relative Domination	Important Value Index
1	*Rhizophora stylosa,*	18.2266	14.0845	21.42658	53.73769
2	*Rhizophora apiculata,*	14.2857	15.4930	13.78491	43.56359
3	*Ceriops tagal*	22.6601	15.4930	20.40906	58.56212
4	*Bruguierra gymnorrhiza,*	1.47778	2.81690	1.444176	5.73891
5	*Rhizophora mucronata,*	1.97044	1.40845	3.652225	7.031119
6	*Avicennia officinalis,*	0.98522	2.81690	0.705227	4.50735
7	*Avicennia lanata,*	12.8079	14.0845	11.74401	38.6364
8	*Avicennia alba,*	6.89655	2.81690	6.798622	16.51207
9	*Xylocarpus moluccensis*,	3.44827	2.81690	2.266696	8.531873
10	*Soneratia alba,*	6.89655	9.85915	7.91291	24.66862
11	*Scyphiphora ydrophylaceae,*	4.92611	7.04225	4.226963	16.19532
12	*Heritiera littoralis*	0.49261	1.40845	0.247782	2.148844
13	*Lumnitzera racemosa*	4.92611	9.85916	5.380837	20.1661

Table 2. Mangrove Species Sapling Density and Diversity

Number	Species	Relative Density	Relative Frequency	Important Value Index
1	*Rhizophora stylosa,*	10.55825	1,234568	45.54417
2	*Rhizophora apiculata,*	26.94175	25.30864	23.16763
3	*Rhizophora. mucronata,*	8.616505	9.259259	23.23655
4	*Bruguierra gymnorrhiza,*	9.5874	13.58025	2.337289
5	*Ceriops tagal,*	12.74272	10.49383	0.86002
6	*Avicennia officinalis,*	0.485437	1.851852	52.25039
7	*Avicennia lanata,*	22.08738	22.08738	13.55478
8	*Avicennia alba,*	0.970874	0.970874	19.81751
9	*Xylocarpus moluccensis*,	2.54855	3.08642	2.326801
10	*Soneratia alba,*	4.126214	4.126214	9.064485
11	*Scyphiphora hydrophylaceae,*	1.092233	4.9383272	2.205442
12	*Xylocarpus molucensis*	2.54852	0.617284	5.634963

Table 3. Mangrove Species Seedling Density and Diversity

Number	Species	Relative Density	Relative Frequency	Important Value Index
1	*Rhizophora stylosa,*	11.16803	0.729927	20.65708
2	*Rhizophora apiculata,*	22.13115	18.24818	40.37932
3	*Rhizophora. mucronata,*	15.88115	10.94891	26.83005
4	*Bruguierra gymnorrhiza,*	9.528689	7.24927	16.82796
5	*Ceriops tagal,*	13.52459	10.21849	23.74357
6	*Avicennia officinalis,*	1.229508	3.649635	4.879143
7	*Avicennia lanata,*	19.56967	24.88759	43.65726
8	*Avicennia alba,*	0.512295	0.729927	1.24222
9	*Xylocarpus moluccensis*,	8.44262	5.839416	14.33678
10	*Soneratia alba,*	3.893443	8.029197	11.92269
11	*Scyphiphora ydrophylaceae,*	0.614754	0.729927	1.344681
12	*Lumnitzera racemosa*	0.102459	3.649635	3.752094

In determining the role of the types of vegetation in the ecosystem, an Important Value Index was needed. This value index was useful for determining the dominance of plant species in the midst of other types of plants. Furthermore, it was important because in a community that has a variety of species, data on the vegetation parameters of the individual species, like on density, frequency, and domination cannot be described as a whole. Therefore, to determine the importance of values related to community structure, the importance value index which was the sum of the values of relative density, relative frequency, and relative dominance had to be calculated (Fachrul, 2007) [8].

The sapling level of the vegetation with dominance parameters was not measured. Furthermore, the INP was obtained by adding up the relative densities and frequency. When the INP of a species was of high value, that species was considered very influential on the stability of the ecosystem.

The data analysis showed that, the highest INP for tree-level vegetation was the *Ceriop tagal* (58.56%), while the lowest was the *Heritierra litolaris* (2.15%). Furthermore, for vegetation, the highest level of INP saplings was *Avicennia oficinallis* (52.25%), while the lowest was *Scyphiphora hydrophylaceae* (2.21%). Whereas the highest INP seedling vegetation was *Avicennia lanata* (43.66%), while the lowest was *Avicennia alba* (1.25%). From the Critical Value Index, it can be concluded that *Ceriops tagal* and *Avicennia* spp species dominated the tree, sapling, and seedling levels.

Species diversity can be used to measure the ability of a community to remain stable in the midst of existing disturbances. Therefore, high species diversity values are usually designated as an indication of environmental stability. The higher diversity value of species was usually due to the more stable ecosystem.

Based on the results of the data analysis using Shannon Index, the Diversity Index obtained a vegetation tree, sapling, and seedling level of 1.66, 1.22 and 1.16 respectively. Those values indicated that the species Diversity Index H was greater/> than 1, and this means that the value of the diversity of the mangrove species was high. This can be proven by the fact that there were 13 species in total. According to Soegianto (1994) in Indriyanto (2006) [9], a community is said to have high species diversity when the community is composed of many types of species. Conversely when there are only a few species, the community is said to have a low species diversity.

Mangrove Animal Condition

Birds

The kinds of birds found along the coastal areas in Taman Jaya of West Seram Regency were Maleo, baikole, and

Masariku Pombo. However, generally, the dominant species were Maleo and *Megapodus fonstenii*.

Mammals

The main types of sea mammals found along the coastal mangrove area were whales and dolphins.

a. *Whales:* According to the field observations and information from the public, the types of whales that traverse the sea and coastal waters were *Megaptera novaeangliae* (Humpback whale) and *Balaenoplera borealis* (Sei whale), which migrate through the area at seasonal intervals.

b. *Dolphins:* Dolphins are also included in the group of marine mammals and were found in almost all marine and coastal waters of the West Seram Regency. The species of this fish found in the coastal waters and marine habits of Taman Jaya was *Tursiops truncatus (common bottlenose dolphin).*

Reptiles

The reptile found in coastal areas was the turtle, and it's zoologically name was *Eretmochelys imbricata (Hawksbill).* This reptile was encountered during the field observations, and a specimen was also captured by fishermen. This indicated that the hawksbills occupying these coastal waters have been living in the environment from their immature to adult stages of life.

Fish

a. ***Pelagicfish:*** Based on observations and interviews with fishermen, the types of small pelagic fish which are often caught in the territorial waters of Taman Jaya are Komu/tuna (*Auxis thazard*), momar/kite (*Decapterus spp.*), kawalinya/trevally (*Selar spp*.), Entry/bloating (*Rastrelliger spp.*), Make/sardines (*Sardinela spp*.), and Puri fish (*Stolephorus spp*.).

b. ***Demersal fish:*** The types of Demersal fish caught were Garopa grouper (*Epinephelus spp)*, Sikuda (*Lethrinus spp*.), Samandar/rabbitfish (*Siganus lineatus, Siganus canaliculatus*), Gurara (*Lutjanus spp*.), and other species.

Mangrove forest has a unique ecological niche that is perfectly suited for fish as described above. This is because its environments provide abundant nutrients, sunlight penetration is not too strong, salinity levels are good, temperature fluctuations in its water is small, it offers protection against pests, and its present condition is suitable for numerous species.

Respondent Characteristics Village Community

30 respondents were selected as the samples of the study, and the age distribution among them was 36-55 years old (34%), 17-35 years old (52%), and 56 years old and above (14%). Age factors affected the participation rate. In general, after reaching a certain age, there was a possibility that the level of one's involvement in various community activities increases public awareness of environmental preservation.

The educational background of the respondents varied. Those that completed primary school were (49%), secondary school (27%), high school (23%), and universities (1%). In addition, their main occupation was farming (40%), a combination of fishermen and farmers (37%), fishermen (9%), employees and builders (4%), and others, such as civil servants.

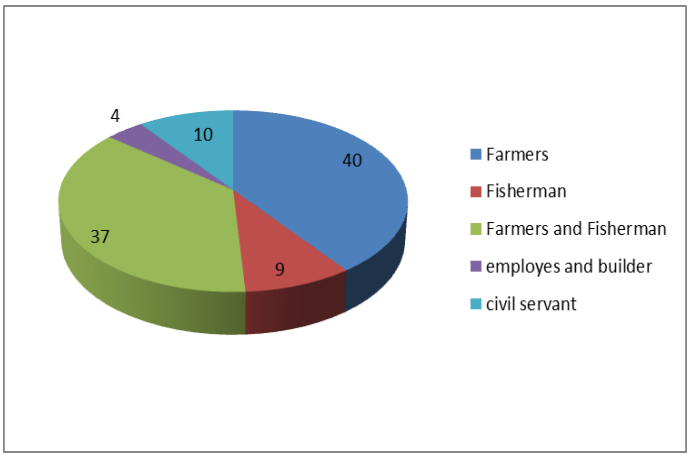

Figure 1. Classification of Public Works in Taman Jaya,Maluku

In general, people in Taman Jaya were supporting sustainable mangrove management. They expected the collaborative mangrove management to involve both the people directly or indirectly, and the community, and help to sustain the mangrove region by halting degradation.

Zoning Mangrove

Environmental conditions outside mangroves areas tend to vary along a gradient from sea to land. In addition, many mangrove species have adapted to this gradient in various ways. Thus, certain species may be better suit for the conditions of an areas, and not of others. This level of adaptation also depends on the combination of local chemical and physical attributes. Therefore, pathways or zones of a single species or associations often grow along the shoreline. Other factors which affects this zoning are shade tolerance, methods of deployment among young mangrove plants and predation by young mangrove crabs.

Watson in Kusmana (1995) [10] argued that mangrove forests can be divided into five sections based on the frequency of the tide. Zoning that is closest to the sea will be dominated by *Avicennia* and *Sonneratia spp* and will grow in the soft mud which have high organic content. *Avicenniaa spp* grows on a substrate that is a bit hard, unlike *Avicennia alba* which grows on those that are rather soft. Zoning that grows on the ground is strong, hard and formed by tide.

The zoning of mangrove is a little higher and usually dominated by *Bruguiera cylindrica*, *Rhyzophora mucronata* and *Rhyzophora apiculata*. Moreover, *Rhyzophora mucronata* is more commonly found in wetter conditions and deeper mud. In general, these trees can grow as tall as 35-40 m. Other trees are also found in these forests, and they include *Bruguiera parviflora* and *Xylocarpus granatum.* However, forests dominated by *Bruguiera parviflora* sometimes have no other tree species.

According to Bengen and Dutton in Northcote and Hartman (2004) [11] zonation of mangroves is affected by salinity, wave and wind tolerance, tolerance of mud (state land), and frequency at which the mangroves are inundated by seawater. Furthermore, changes to the mangroves are very dynamic, and occur due to sedimentation and erosion. The adaptability of the species determines the Composition of each type of zoning.

Zoning of mangroves in Taman Jaya was conducted based on function, Therefore, the mangroves were divided into protection and utilization zones. The mangrove protection zone should be maintained as a green belt, where it serves as a mitigating factor and adaptation to climate change. Moreover, this zone was characterized by the growth of mangrove species.

The primary and secondary mangrove utilization zones should be reserved for the interest of the public interest, or its management by the relevant agencies. This recommendation is consistent with the statement by Pattimahu *et al* (2013) [12] that the lack of zoning of mangroves based on land-use in the study site is one of the indicators that need to be considered, to avoid land-use conflicts.

CONCLUSIONS

Ceriops tagal, Rhizophora apiculata, and *Avicennia lanata* all showed important index value for the tree, sapling and seedling categories. This indicated that the species played a major role in the mangrove ecosystem.

The mangroves were zoned by dividing the forest into zones of protection and utilization. Moreover, the mangrove protection zone needed to be maintained as a green belt, and also a mitigation and adaptation to climate change. While the mangrove utilization zone was intended for the benefit of the community and others.

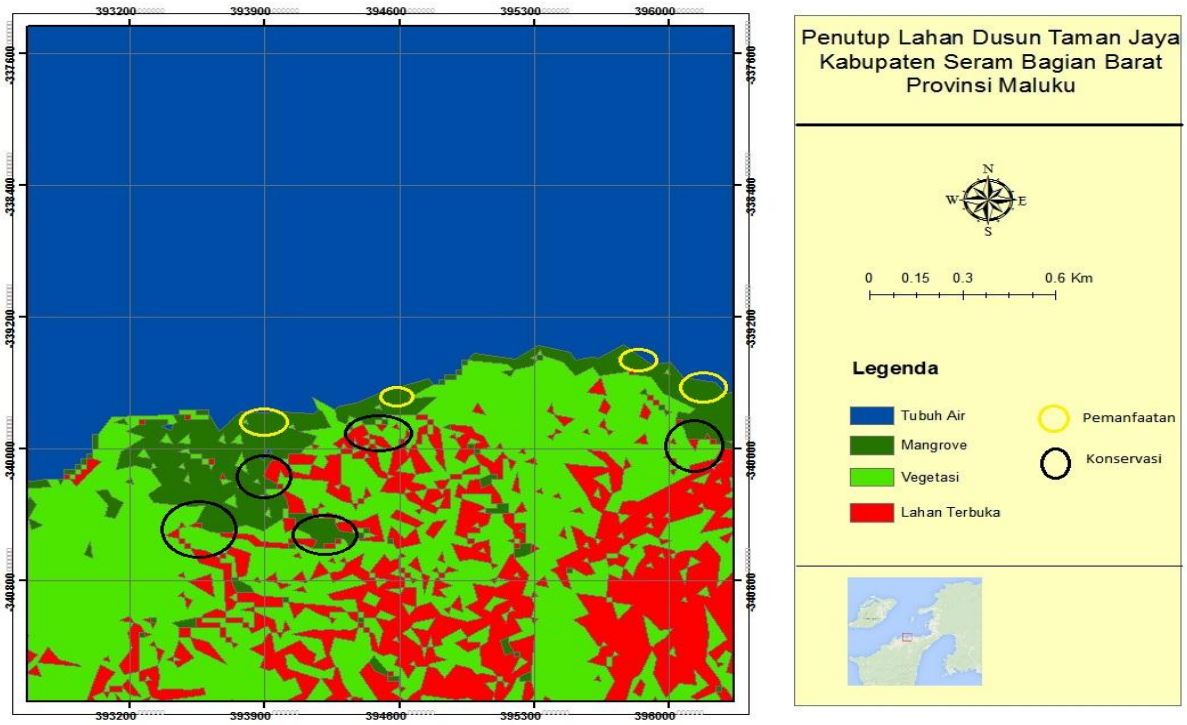

Figure 2. Mangrove zoning map based on the function designation in Taman Jaya.

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REFERENCES

[1] Farley, *et al*., 2009. Conserving Mangrove Ecosystems in the Philipines: Transxending disciplinary and Institutional bolders. Environmental Management, Volume 45, Number 1, January,2010.DOI:10.1007/s00267-009-9379-4

[2] Murdiyanto, B., 2003. Know, Maintain and Preserve Mangrove Ecosystem. Directorate General of fisheries. Department of Marine and Fisheries. Jakarta

[3] Pattimahu, D, V *et al*. 2010. Mangrove Ecosystem Management Policy in the District of West Seram Maluku. Graduate School of IPB Bogor. Dissertation.

[4] King R.C Turner, et al. 2000. The Mangrove communities of Danjungan Island Cavayan Negros Occidental, Philipines Submission is Silirman Journal. Philipines.

[5] Ludwig, Reynold, 1988. Statistical Ecology: A Primer on Methods and Computing. Singapore (SG): John Wiley and Sons.

[6] Noor et al, 2006. Noor, Y.R., Khazali, M., Suryadiputra, I.N.N., 2006.Introduction Guide Mangrove in Indonesia. PHKA/WI-IP, Bogor.

[7] Kusmana, C., Sri.W., Iwan.H., H. Prijanto. P, Cahyo, W.Tatang. Just now. T., Yunasfi. 2003. Mangrove Rehabilitation Techniques Bogor.

[8] Fachrul, M,F. 2007. Bioecological Sampling Methods. Bumi Aksara Press. Jakarta.

[9] Indriyanto. 2006. Forest of Ecology. Bumi Aksara Press Jakarta.

[10] Kusmana,C,1995. Mangrove Forest Management in Indonesia. Bogor: Forest Ecology Laboratory, Faculty of Forestry. Bogor Agricultural Institute.

[11] Bengen and Dutton in Northcote and Hartman ,2004. Interaction : Mangrove, Fisheries and Forestry Management in Indonesia. H.632-653. In Northcote .T.G and Hartman (Ed) Worldwide Watershed Interaction and Mangement. Blackwell Science. Oxford.UK.

[12] Pattimahu, D, V *et al*. 2017. Sustainability Mangrove Ecosystem Management Analysis (a case study from Dusun Taman Jaya West Seram Regency Maluku). International Journal of Applied Engineering Research ISSN 0973-4562.Vol.12. Number 24 . pp. 14895-14900. Research India Publication.