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Impact of salt pond industry on the changes of mangrove ecosystem in Kupang Bay, Timor Island, Indonesia

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Abstract. *Kapitan EM, Arjana IGB, Santoso P. 2020. Impact of salt pond industry on the changes of mangrove ecosystem in Kupang Bay, Timor Island, Indonesia. Biodiversitas 21: 63-73.* The study of the effect of salt pond industry on changes in mangrove ecosystems in Kupang Bay was carried out between July and September 2018. This study aims to examine the effect of the salt pond area and salt pond production on the dominance and diversity of mangrove population. The study was conducted by survey method through direct observation in the field and community interviews at three research stations. Data on mangrove vegetation were collected using the line transect method. The results of the study found 9 (nine) species from 4 (four) families. Overall tree density is relatively rare while seedling levels are categorized as high. The highest frequency types for tree level, saplings, and seedlings, namely *Ceriops tagal*. The results of the regression analysis showed that the area of salt ponds and the production of salt ponds did not have a significant effect on dominance and diversity of mangrove population ($p>0.05$). However, there was a positive relationship between salt pond area and salt pond production with the dominance of the mangrove population. Whereas, both salt pond area and salt pond production with a diversity of mangrove populations showed a negative relationship. These results indicate a tendency that an increase in both salt pond area and salt production will increase the dominance of the mangrove population, but decrease its diversity. This shows that the influence of the salt pond area and salt pond production has not had a significant effect on the dominance and diversity of mangrove populations in the current conditions.

Keywords: diversity, dominance, ecosystems, mangroves, production, salt pond

INTRODUCTION

East Nusa Tenggara (NTT) is an archipelago Province consisting of 566 islands, with a length of the coastline of ± 5,700 km and has a sea area of ± 200,000 km² outside the waters of the Indonesian Exclusive Economic Zone (IEEZ). This province has a wealth of marine resources and fisheries resources that are potential for increasing community income. The potential of coastal and marine resources in NTT for regional economic contributions, needs to be explored and pursued optimally while maintaining the carrying capacity of the coastal and marine environment for the improvement of the community's economy as well as NTT's regional income.

One of the marine and fisheries resources that can be utilized by the NTT community, especially residents who lived around the coastal area, is the mangrove ecosystem. Kupang Bay with a long coastline of 17,578 m with a total area estimated at 1,106 ha, making it an area that has mangrove forests and can be utilized by coastal communities. Mangrove ecosystems have long been used by coastal communities in the Kupang Bay as a source of livelihood in the form of fishing, shrimp, crabs, and shellfish (Santoso et al. 2015). The existing activities are not limited to hunting or fishing activities but also cultivation activities that utilize the suitability of mangrove conditions for milkfish ponds and salt. In addition, this ecosystem plays an ecologically important role as a spawning ground, nursery area, and feeding ground for a number of species in Kupang Bay.

Kupang Bay is an inseparable coastal area of the sea waters of Kupang Regency, where it has an area of marine waters reaching 4,086.33 km^2 with a coastline length of 551.61 km. This region has a mangrove population that stores a wealth of marine resources (fish and other marine products), which are quite large but have not been managed optimally to improve the regional economy (BPS-Statistics of Kupang Regency, 2020). Kupang Bay in NTT Province is also designated as one of the Marine Nature Tourism Parks (TWAL) in Indonesia with an area of 50,000 ha. This status is specifically regulated since 1990 concerning the conservation of natural resources and its ecosystem, where its function and role is set as conservation areas and the implementation of natural marine tourism. Although mangrove ecosystems are included in the recoverable resources, if the function or conversion is carried out on a large scale and continuously without any sustainability considerations, the ability of the ecosystem to recover itself is not only hampered but also does not take place ideally, because of the weight of the changes. Damage to the mangrove ecosystem has a large impact on ecological, economic, and social. Mangrove degradation is usually caused by conversions for settlements, conversions for ponds (both salt ponds and fish ponds), timber extraction, and pollution (Hakim et al. 2017; Santoso et al. 2015).

The area of mangrove ecosystem in Kupang Regency, according to the statistics data 2008 is 11,352.92 Ha, and in 2019 the remaining mangrove forest area is 3,266.10 Ha. This condition shows that from 2008 to 2019 there was a decline in the area of mangrove forests in Kupang Regency, which was an area of ± 8,126.82 ha, and possibly already converted into ponds and other uses (BPS-Statistics of Kupang Regency, 2020). The degradation of mangrove ecosystems in Indonesia has been going on for a long time and threatens the preservation of the world's coastal and marine biological resources, because Indonesia has the largest mangrove ecosystem with the highest biodiversity in the world. Mangrove ecosystems in the Kupang Bay TWAL also have environmental degradation due to uncontrolled mangroves utilization. Human activities such as the making of brackishwater ponds for fish or salt pond, deforestation, and environmental pollution, are the main causes of mangrove degradation. In addition, mangrove degradation can also be caused by reclamation, sedimentation, mining, and natural factors such as storms or tsunamis (Kusmana and Sukwika 2018; Kerry et al. 2017).

The development of salt ponds around Kupang Bay, whose location is in the mangrove area, began in 2009 since the government launched a national salt self-sufficiency program. This region has the potential to develop salt ponds of 39.2%, with an existing area of 7,700 hectares and potential production of 870,000 tons/year. The extensification of salt land in Bipolo Village, Sulamu District, Kupang Regency by PT. Garam that has previously been carried out in 2016 was 55 ha become 318 ha in 2020. Its supporting physical superiority is having a high saltwater content due to the ideal climate and abundant sunshine that tend to be even hot and dry, making it a suitable area for salt processing. Of course, this is an attraction for residents or the public and the government and the private sector in an effort to produce salt both conventional and with Geomembrane Filter (TuF) Technology. Through the PUGAR (Program of the People’s Salt Industry Development) the Governor of East Nusa Tenggara wants to realize the salt self-sufficiency in Kupang Regency. This program has been started in 2011 until now which is based in the Merdeka Sub-District, East Kupang District, Bipolo Village, and Oeteta Village, of Sulamu District.

Deforestation of mangrove for development of salt pond industries will certainly disrupt the existence of the surrounding mangrove ecosystem. Various impacts will be sensed both by biota that interacts in the mangrove area itself and by people who depend on their lives by utilizing life around the mangrove area. Based on the description above, it is necessary to conduct a study to determine the effect of salt pond industry on changes in mangrove ecosystems. This study aims to examine the effect of the total area of salt pond and production of salt on the dominance and diversity of mangrove species in Kupang Bay.

MATERIALS AND METHODS

Study area

The study was carried out between July and September 2018 in the Kupang Bay area on 3 (three) research stations, namely in Merdeka Sub-District (East Kupang Sub-District), Bipolo Village and Oeteta Village (Sulamu Sub-District). The three villages are located on the Kupang Bay, West Timor, Indonesia. The location is the mangrove ecosystem area near the business activities of salt ponds (Figure 1).

This study used a quantitative approach to survey methods. The data collection techniques in the survey method were sampling techniques for collecting data on mangrove ecological condition and interview techniques with questionnaire guidelines for collecting respondents' data. The population in this study was dominantly salt farmers in the Kupang Bay, which were concentrated in 3 (three) locations, i.e. Merdeka Village (East Kupang Sub-District), Bipolo and Oeteta Villages (Sulamu Sub-District). Variables studied included mangrove ecological condition, total area of salt ponds and production of salt.

Procedures

Collection of the mangrove ecological data was conducted by the line transect method. The stages of data collection were as follows: The location determined from the observation of mangroves represents the study area, and can also represent each zone of mangrove in the study area. The sampling steps were as follows: At each location, a conceptual observation transect was determined based on the representation of the location of the study at each observation station. After that, line transects from the sea to the land are determined (perpendicularly from the sea to the land as long as in the mangrove ecosystem). In each zone, mangrove vegetation used transect lines, with sample plots located along the transect line, randomly placing plots in the form of squares measuring 10 x 10 m2 for tree levels, size 5 x 5 m2 for sapling level, and size 2 x 2 m2 for seedling level as much as 3 (three) sample plots with plot distance on each transect of 50 m. In each predetermined plot, the determination of each type of mangrove plant is present, calculate the number of individuals per species, and measure the circle of the stems of each mangrove tree at breast height, about 1.3 m.

The method used in data collection of production and the total area of salt pond industry were observation and interview. Retrieval of the respondents' data was carried out with the assistance of questionnaires by direct interview with each respondent in the research area. Determination of the sample is done by a purposive sampling method, namely the selection of respondents intentionally with certain sample requirements. The requirements of the respondents selected in this study were salt farmers who owned farmland and communities as cultivators of salt ponds.

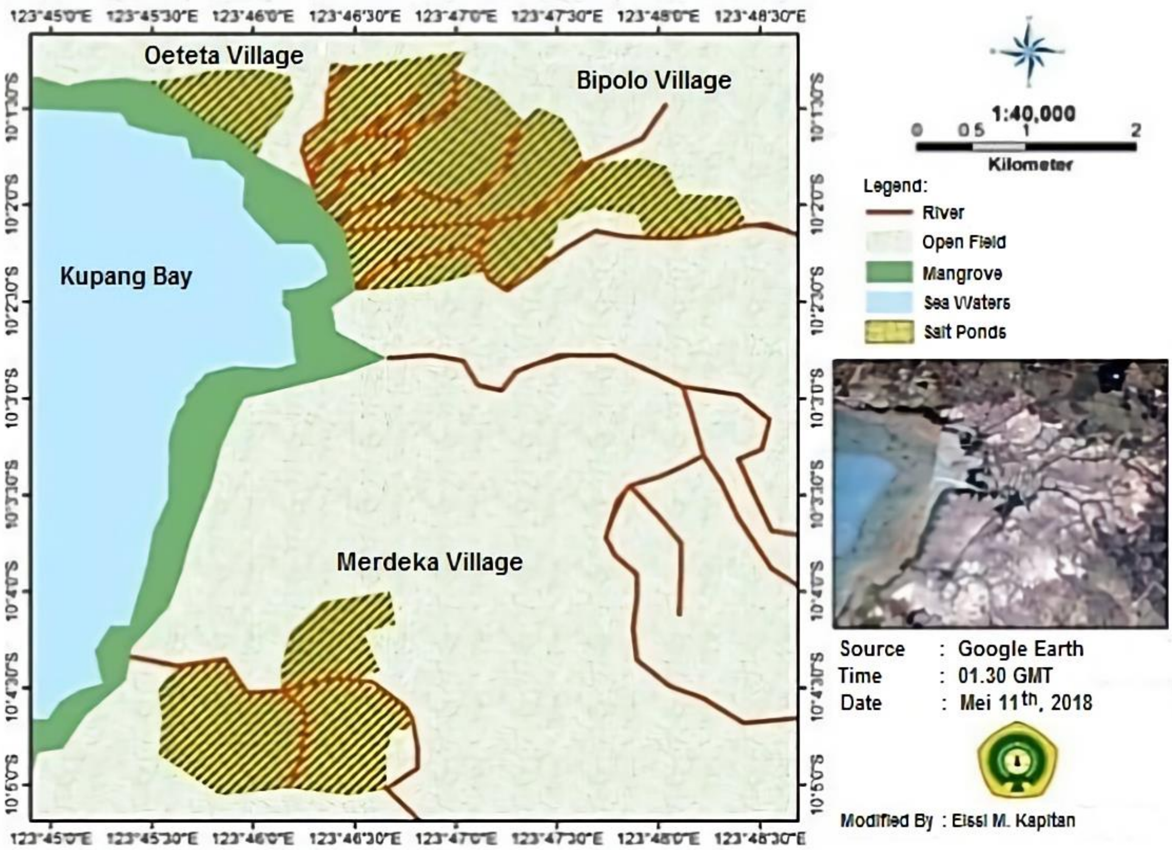

Figure 1. Location of salt ponds area in Kupang Bay (Timor Island), East Nusa Tenggara, Indonesia

Data analysis

Analysis of the mangrove ecological condition includes diversity index, dominance index, dominance value, relative density, relative frequency, relative closure and importance value index, with the following formulas:

Diversity index (H ')

The Shannon-Wienner diversity index is used to determine species diversity at each growth rate (Odum 1971) with the following formula:

$$H' = -\sum pi \ln pi \text{ atau } H' = -\sum_{i=1}^{s} [\frac{ni}{N}] \ln [\frac{ni}{N}]$$

where:
H' = diversity index
Pi = ni/N
ni = Total of individual of the i^{th} species
N = Total number of the whole individual

Categories of the Shannon-Wienner diversity index (H') are referred to:
H'<1 = Low diversity
1 <H'≤3 = Moderate diversity
H' >3 = High diversity

Dominance index (C)

Dominance index is used to determine the extent to which a biota group dominates another group. Significant dominance will lead to unstable and depressed communities. Dominance index is calculated based on the formula of the index of dominance of Simpson (Odum 1971) as follows:

$$C = \sum (ni/N)^2$$

Where:
C = Dominance Index
ni = Total of individual of the ith species
N = Total number of the whole individual

Category of dominance index:
C = 0 < C < 0,5 = Low Dominance
C = 0,5< C < 0,75 = Moderate Dominance
C = 0,75< C <1 = High Dominance

Dominance index is used to determine the extent to which a biota group dominates another group. Significant dominance will lead to unstable and depressed communities. Dominance index is calculated based on the greater dominance index value (C), the greater the tendency for certain species to dominate.

Dominance

The dominance of certain species can be determined by using the Simpson Dominance Index as follows:

$$D = \sum \left[\frac{(ni-1)}{(N-1)}\right]^2$$

Where:
D : Dominance
ni : Total of individual of the i^th species
N : Total number of the whole individual

Density (Di)

Mangrove species density values can be calculated using the formula:

$$Di = \frac{ni}{A}$$

Where:
Di : density of the i^th species
Ni : total number of individu of the i^th species
A : total area sampling/plot

Relative density (RDi)

The relative density value of mangrove species can be calculated using the formula:

$$RDi = \frac{ni}{\sum n} \times 100\ \%$$

Where:
RDi : relative density of the i^th species
ni : total number of the i^th species
∑n : total stand of all species

Frequency species (Fi)

Mangrove species frequency values can be calculated using the formula:

$$Fi = \frac{pi}{\sum p}$$

Where:
Fi : frequency of the i^th species
pi : total sampling/plot where found the i^th species
∑p : total sampling/plot of the whole species

Relative frequency (FRi)

The relative frequency value of mangrove species can be calculated using the formula:

$$RFi = \frac{Fi}{\sum F} \times 100\ \%$$

Where:
RFi : relative frequency of the i^th species
Fi : frequency of the i^th species
∑F : total number of sampling plots

Important value index (IVI)

The importance index of mangrove species can be calculated using the formula:

$IVI_{Trees} = RD_i + RF_i + RC_i$
$IVI_{Saplings}$: $RD_i + RF_i + RC_i$
$IVI_{Seedlings}$: $RD_i + RF_i$

The importance of a mangrove species on the sapling level ranges from 0-300 and seedlings level 0-200. This Important Value provides an overview of the influence or role of a mangrove plant species in mangrove communities.

Analysis statistic

The research data were analyzed by analysis of variance (ANOVA) using software SPSS 24. Whereas the correlation between diversity and dominance of mangroves with the total area of salt ponds and salt production was analysis with the formula as follows:

$$r^2 = \frac{\sum(Yi - \bar{Y})^2 - \sum(Yi - \bar{Y}i)^2}{\sum((Yi - \bar{Y})^2}$$

Categories of the correlation are:
r = 0.07-1.00 = high correlation
r = 0.40-0.69 = moderate correlation
r = 0.20-0.39 = low correlation
r = < 0.20 = no correlation

While the analysis of relationship between diversity and dominance of mangroves with the area of salt ponds and salt pond production capacity have used linear regression test.

RESULTS AND DISCUSSION

General overview of location dan inhabitant

The research location is the coastal area stretching of the coast of Kupang Bay i.e. Merdeka Village (East Kupang Sub-District), Oeteta, and Bipolo Villages (Sulamu Sub-District). These three villages have a region that directly boundaries of the Kupang Bay. Most of the land surface conditions are sloping (<15°) and situated at a height of 26-500m from mean sea level (msl). The climatic conditions are dry climate influenced by monsoons, with a short rainy season between December and April. The average air temperature ranges between 24 and 31°C, with an average rainfall reaching 2,000 mm per year.

The resident in Merdeka, Oeteta and Bipolo Villages varies considerably according to the number of households, number of population, type of work and level of education. The population in Merdeka Village is higher (3,469 people) compared to the Oeteta Village (1,368 people) and Bipolo Village (844 people), although the area is smaller (10.50 km^2) than the two villages above namely Oeteta 42.34 km^2 and Bipolo 41.47 km^2 with a density of kilometers reaching 330 people (BPS-Statistics of Kupang Regency 2020).

The livelihoods of the inhabitant in these three regions are still dominated by the agricultural sector, especially food crops that are characterized by dryland farming, which is as much as 67.09% or 1,763 people. Whereas fishermen are only 11.23% or 295 people, while 21.68% other livelihoods or around 570 people. Based on livelihoods, the population in these three regions basically has an agrarian culture, even though these three regions are coastal villages.

Salt farmers who are currently actively operating salt farms in Merdeka Village are currently 47 people, in Oeteta Village there are 14 people and in Bipolo Village there are 13 people, with a composition of 100% are male, with a relatively good level of education. The average level of formal education of respondents is 23.7% of elementary school graduates, 18.6% of junior high school graduates, 32.2% of high school graduates, 3.4% of graduates are undergraduate and 22.1% do not graduate from school.

Being a salt farmer is the main job of all respondents at this time where they use their time to operate in salt fields for 6-8 hours every day during the dry season while during the rainy season most respondents do activities as farmers and some of them carry out activities as fishermen. Salt farmers in managing salt fields in the three regions apply the salting process using conventional techniques and intensification techniques. Conventional techniques use a crystallization table without using a pedestal, so that the resulting salt is rather gray due to the possibility of mixing dust and soil. While the intensification technique is to use a Geo-membrane media as a base from the crystallization table, so that the salt produced is a pure white color because it is not contaminated by soil or mud because it is insulated by a Geo-membrane. The difference between these two methods of salt production is that the quantity and quality of this salt are also different. This can be distinguished in plain view from the shape and color.

Salt production in these three regions varies based on land area and the techniques applied by each salt farmer. In addition, weather conditions also influence salt production. The total area of salt ponds and the amount of salt production in the three regions i.e. Merdeka Village has the total area of 56 ha (38%) with the amount of salt production reaching 754,800 tons (33%), Oeteta Village has the total area of 64.28 ha (44%) with production of salt reached 1,380,300 tons (61%), while Bipolo village has the total area of 26.4 ha (18%) with salt production of 138,760 tons (6%).

The business activities of salt ponds in 3 (three) locations actually existed for a long time and naturally carried out in groups for the common interest in accordance with their work, namely the people's salt farm business, because generally more than one person is usually employed up to 4 people. Public salt farmers in the three regions currently process salt depending on the size of the salt ponds they have to work on and on average 0.5-10 ha/person (family head). However, the existence of a group of salt farmers was officially formed in 2011 when the program of PUGAR (Program of the People’s Salt Industry Development) was launched from the Ministry of Marine Affairs and Fisheries Indonesia.

During that year salt production gradually increased because the PUGAR provided technological innovations in the process of making salt starting from irrigation channels, pumping, production processes to salt storage systems. Between 2014 and 2015, an innovative filter technology was implemented. This thread is expected to improve the evaporation process of water to reduce the time of making the salt, while the filter is expected to filter out the impurities that attach to the salt can be deposited on the filter. With the salt pond intensification system by the government, salt farmers are also provided with a membrane that is placed on the crystallization table so that the salt produced looks pure white.

The raw materials of salt produced are usually sold to companies that use salt raw materials or to salt cooking communities from the area around the location of salt or from outside the area such as from Oebelo Village, as well as from outside the Kupang Regency area. The selling price of the raw materials of salt varies greatly. During the dry season where the amount of production increases, the price is 500 to 600 IDR/kg, while in the rainy season when the salt does not produce the price is 2,500 IDR/kg. Usually, these salt entrepreneurs if in the dry season with a low selling price they sell their salt products only for sudden needs such as the needs of school children or sick children or for their daily needs and to buy sacks as a place to store salt raw materials while the rest are raw materials This salt is collected for sale during the rainy season. The salt business is only carried out during the dry season, while during the rainy season these farmers carry out activities in agriculture to cultivate rice or secondary crops and some return to search for products in the sea such as catching Shrimp, crabs, fish and other marine products as a source their food and the rest are sold around their neighborhood.

Ecological condition of mangrove

Data collection of Ecological Condition of Mangrove in Kupang Bay was carried out on 3 (three) observation stations, namely: Merdeka Village (S: 10º05'14.74" and E: 123º45'05.53"), Oeteta Village (S: 10º01'41.51" and E: 123º45'26.10"), and Bipolo village (S: 10º02'27,64" and E: 123º46'15.06"). Based on the results of the identification of mangroves in the three observation locations, it shows that overall there are 9 (nine) mangrove species from 4 (four) families found in 3 (three) observation locations: Merdeka Village= 4 (four) species of mangroves: *Rhizophora mucronata*, *Ceriops tagal*, *Avicennia alba*, and *Sonneratia alba*. Oeteta Village= 7 (seven) mangrove species: *Rhizophora apiculata*, *Rhizophora stylosa*, *Ceriops tagal*, *Ceripos decandra*, *Avicennia alba*, *Sonneratia alba*, and *Sonneratia caseolaris*. While in Bipolo Village, 9 (nine) species were found: *Rhizophora apiculata*, *Rhizophora stylosa*, *Rhizophora mucronata*, *Ceriops tagal*, *Ceriops decandra*, *Avicennia alba*, *Sonneratia alba*, *Sonneratia caseolaris*, and *Luminitzera racemosa*. All species originating from 4 families: Rhizophoraceae, Avicenniaceae, Combretaceae and Soneratiaceae.

The dominance index (C) values at each research station ranged between 0.03 and 0.84. The dominance index value obtained is categorized as low to high. Bipolo village has a relatively low dominance index value, which ranges between 0.03 and 0.23. For Oeteta village, it has a moderate dominance index value, ranging between 0.2 and 0.33 while the Merdeka village has a high dominance index value ranging between 0.51 and 0.84 (Figure 2).

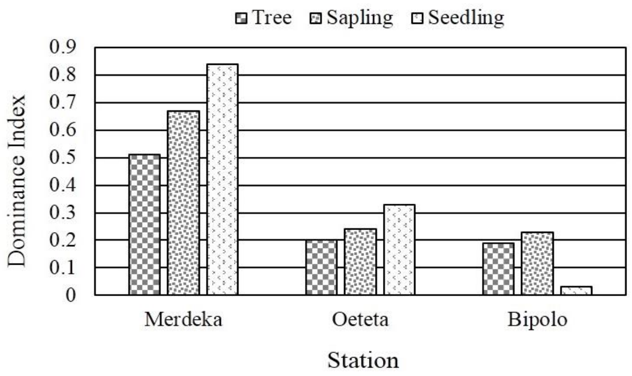

Figure 2. Dominance index of mangrove

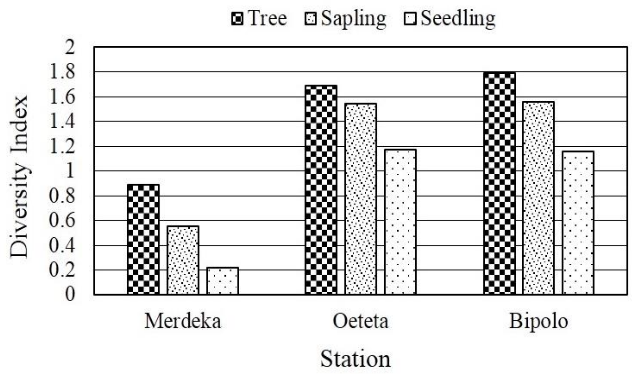

Figure 3. Diversity index of mangrove

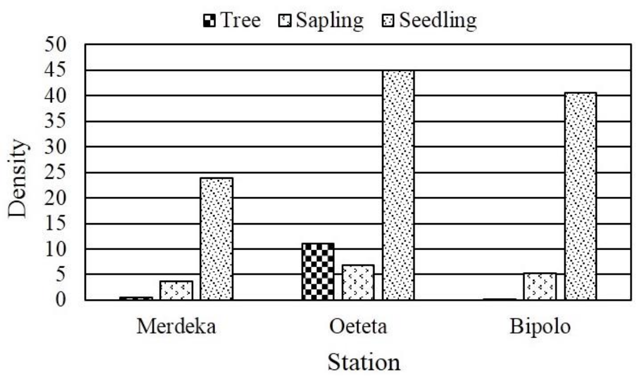

Figure 4. Density of mangrove

The range of the diversity index (H') value for each research station, namely the Merdeka Village, ranges from 0.22-0.89, this value is relatively low because of the value of H '<1. For Desa Oeteta the value of the diversity index (H ') ranges from 1.17-1.69, this value is classified as moderate because the value of H' 1 <H '<3, while for the Village of Bipolo the range of H' is between 1.16-1.79 and this value is also classified as moderate. This is in accordance with the criteria for the diversity index value (H ') according to Odum (1971) that if the value H' <1 is categorized as low, if the diversity index value 1 <H '<3 is categorized as medium, whereas if the value of H'> 3 is categorized as high (Figure 3).

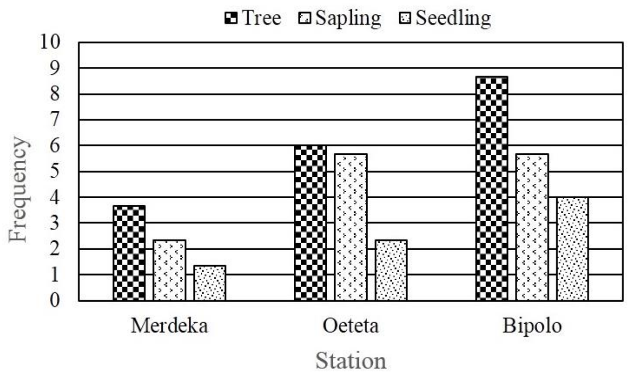

Figure 5. Frequency of mangrove

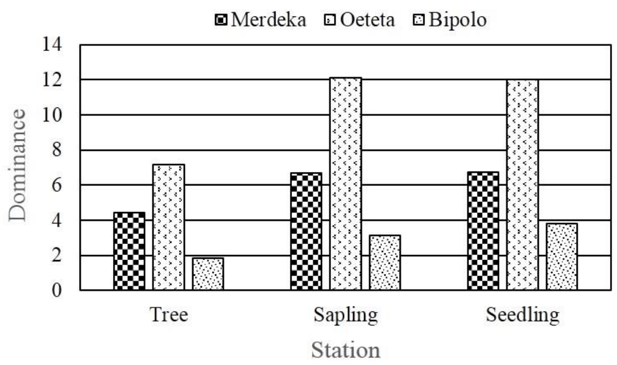

Figure 6. Dominance of mangrove

The density of the mangrove species studied consisted of several levels, namely the level of trees, saplings, and seedlings. From the overall research station, the density type at the tree level is less than the saplings and seedlings (Figure 4).

The highest frequency of mangrove species is at station 3 (Bipolo Village), where the nine of mangrove species are found in this region and have high-frequency values both for the tree, sapling, and seedling categories. This shows that the level of presence of mangrove species is evenly distributed. The lowest frequency of mangrove species is at station 1 (Merdeka Village), where only 4 mangrove species are found. This condition indicated that the distribution of mangrove species in this region is uneven (Figure 5).

The high dominance value of species for both the tree, sapling, and seedling categories is the *Ceriops tagal* (Figure 6). This type has a high dominance value because the characteristics of the research location are in accordance with the characteristics desired by the mangrove species. Besides that, the condition of the substrate which is generally sludge containing organic material is very suitable for the growth of its species so that this type of mangrove is spread evenly at each observation station.

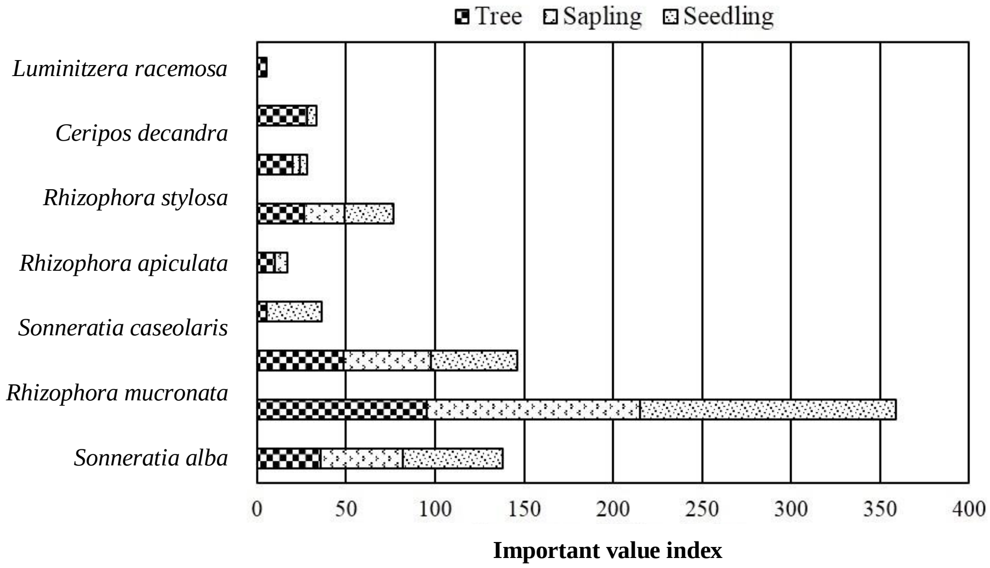

Figure 7. Important value index of mangrove

All of stations, there are 3 (three) categories of vegetation found that had the highest IVI and were spread both at the level of trees, saplings, and seedlings, namely *Ceriops tagal, Avicennia alba,* and *Sonneratia alba.* These three species play quite an important role in the Kupang Bay coastal environment. IVI shows the representation of mangrove species that play a role in ecosystems with a range of values between 0-300 (Figure 7). The high value of IVI shows that a species has better adaptability, competition, and reproductive capacity compared to other plants in a particular environment.

Effect both of total area and production of salt ponds on dominance of mangrove

The ANOVA test on the data on land total area to the dominance of mangroves showed that the land area did not significantly influence the dominance of mangrove species ($p>0.05$). There was a positive relationship between the two variables (Y = 0.152 + 0.003X). The coefficient is positive, so the implication that there is a positive relationship between land area and dominance, the more extensive the area of salt ponds, the higher the dominance. The results of the correlation analysis showed that there was no significant correlation between the area of salt ponds and the dominance of mangroves. However, the direction of the relationship was positive (r = +0.316). It would be said that the land area is positively related but not significant to the dominance of mangroves.

The ANOVA test results showed that the production of salt ponds did not significantly influence the dominance of mangrove species ($p>0.05$), but there was a positive relationship between the two variables (Y = 0.296 + 8.105E-6X). The coefficient correlation is positive (r =+0.925). It would be said that there is a positive relationship between salt pond production and dominance, the higher the production of salt ponds, the higher the dominance of certain mangrove seedlings stage. The results of the correlation analysis showed that there was no significant correlation between the production of salt ponds with mangrove dominance where the significant value was 0.947>α (0.05), but the direction of the relationship was positive (r = +0.026). It can be said that salt pond production is positively related but not significant to mangrove dominance.

Based on the results of the observation, the location that has the highest mangrove dominance is in the Merdeka Village, both for the tree category (C = 0.51), saplings (C = 0.67), and seedlings (C = 0.84), while those with dominance the lowest type of mangrove was Bipolo Village, both for the tree category (C = 0.19), saplings (C = 0.23), and seedlings (C = 0.03).

Land area and high salt pond production are found in the Merdeka Village (56 Ha, production of 754,800 tons/year) and Oeteta Village (64.28 Ha, production of 1,380,300 tons/year), while the lowest is Bipolo Village (26.4 Ha, production 138,760 tons/year). The high dominance of mangrove species is also found in these two locations (Merdeka and Oeteta Villages) while the lowest dominance is in Bipolo Village. This may occur because the substrate conditions support mangrove growth and the presence of growth mangroves are more adaptive to environmental changes.

Effect of total area and production of salt ponds on mangrove species diversity

The ANOVA test results, the land area data on diversity shows that the land area does not significantly influence the diversity of mangrove species (P> 0.05), and there is a negative relationship between the two variables (Y = 1,930-0,010X). The coefficient is negative, so it can be said that there is a negative relationship between the area of the land and the diversity of mangrove species, where the more the area of salt ponds, the lower the diversity of mangrove species.

The results of the correlation analysis showed that there was no significant correlation between the area of salt ponds and the diversity of mangroves where the significant value was 0.334> α (0.05), but the direction of the relationship was negative (r =-0.365). It can be said that the land area is negatively and not significantly related to the diversity of mangrove species.

However, the Result of ANOVA test showed that salt pond production did not significantly influence the diversity of mangrove species (P> 0.05), and there was a negative relationship between the two variables (Y = 1.507-6.551E-5X). The coefficient is negative, so it can be said that there is a negative relationship between the production of salt ponds and the diversity of mangrove species, where the higher the production of salt ponds the lower the diversity of mangrove species.

The results of the correlation analysis showed that there was no significant correlation between the production of salt ponds with the diversity of mangrove species where the significant value was 0.843> α (0.05), and the direction of the relationship was negative (r =-0.077). It can be said that salt pond production is negatively and not significantly related to the diversity of mangrove species.

Based on observations, the location that has the highest mangrove diversity index is in Bipolo Village (H' = 1.79) for the tree category while the one with the lowest mangrove species diversity index is Merdeka (H' = 0.89). For the puppies category that has the highest diversity index in the Oeteta Village (H '= 1.69). While those with the lowest index of diversity of mangrove species are in Merdeka Village (H '= 0.55). For the seedling category which has the highest diversity index in the Oeteta Village (H '= 1.17) while the lowest mangrove species diversity index is in the Merdeka Village (H' = 0.22).

Discussion

In the Merdeka Village, the value of the diversity index is low because there are species that dominate this region, which is of the type of *Ceriops tagal* which dominate other species in this region. Oeteta and Bipolo villages have a diversity index value in the moderate category. This is presumably due to the condition of the substrate and a considerable distance from the sea. A community is said to have lower species diversity if the community is composed of a few species and only a few species dominate.

Factors that determine changes in species diversity in one ecosystem, namely time, space heterogeneity, competition, predation, environmental stability, and productivity. During the geological period, there will be changes in environmental conditions which result in many individuals who cannot maintain their lives, but there are also groups of individuals who are able to survive continuously for a relatively long time as a result of the evolutionary process (Utina et al. 2019).

Through the analysis of dominance index, it can be seen that very few species dominate the place because of its moderate dominance, which causes a moderate level of diversity, because if the dominance is high the diversity is low, and vice versa. Furthermore, the dominance index is high, then dominance is centralized in one species. But if the dominance index value is low, then dominance is centralized in some species (Lignon et al. 2011; Hakim et al. 2017; Fredrik et al. 2019).

Mangrove species that have the highest density are in the seedling category, while the lowest density is in the tree category. One of the factors that influence the low value of tree species density is the root condition which is classified as large so that the growth of the mangrove becomes less optimal, thus the low density of species in the tree category causes incoming sunlight to illuminate the mangrove forest land. This makes the seedlings and saplings grow effectively (Sambu et al. 2014). High density in the seedling category is due to the low density of the tree so that the sun needed by the seedlings is not blocked by the tree, so it supports the growth of the seedlings. Seedling regeneration in mangrove forests is an important part of the process of secondary succession, then the growth of species of natural mangrove seedlings has a close relationship with the availability of the parent trees. The high value of the density of this species is also influenced by the closing value of sapling species which are still relatively small with a diameter of <10 cm. This factor supports the optimal growth of mangrove species (Hakim et al. 2017; Fredrik et al. 2019).

The species with the highest density and has the most influence in the three study sites is the *Ceriops tagal* of all categories. This condition is caused because this species is a type of mangrove whose growth is tolerant of environmental conditions, especially to the condition of the substrate which likes the clay substrate and grows well in areas that are inundated by high tides and tides as well as a very widespread of seeds and occurs throughout the year (Kusmana and Sukwika 2018; Utina et al. 2019). *Ceriops tagal* is a characteristic of the development of the final stages of coastal forests, as well as the initial stages in the transition to terrestrial vegetation. This species likes clay substrates and the flowering occurs throughout the year (Awn et al. 2016).

The distribution of species of a mangrove community can be determined by calculating how much the frequency value or the level of presence of the species, high-frequency values indicate that the species has an even distribution and is often found in a forest area. Vice versa if the frequency value is low then the distribution in a forest area is not evenly distributed (Krebs 2009; Kerry et al. 2017).

Ceriops tagal is a pioneering plant or a pioneer and includes species that have seeds that can germinate while still on the parent are very supportive of the widespread process of other species. The dependence of pioneer plant species on soil types is shown by the *Rhizophora* genus which is a common characteristic for muddy soils mixed with organic matter (Awn et al. 2016; Utina et al. 2019). While the specific life cycle of the mangrove species (*Rhizophora* sp.) with seeds that can germinate while still in the parent plant is very supportive of the broad distribution process of this species in the mangrove ecosystem (Kerry et al. 2017). These species are spread evenly in almost all mangrove ecosystem areas in Merdeka Village, Oeteta Village, and Bipolo Village. This indicates that these species are the most adaptive.

Species with the highest importance show species mastery value in a community and are able to take advantage of environmental conditions so that they can grow better than other species (Lignon et al. 2011). Species with the lowest dominance value are depressed, unable to develop and adapt so that growth is unstable. The importance of a species can be used as an indication that the species are considered dominant by having a higher relative density, relative frequency, and relative dominance value compared to other species (Sambu et al. 2014).

Important Value Index (IVI) is a quantitative parameter that can be used to express the level of species dominance in mangrove communities. Furthermore, the IVI value reflects the existence of the role (dominance) and structure of mangrove vegetation in a location. The dominant species in a plant community will have a high importance value index, so the most dominant species of course has the greatest importance value index (Krebs 2009).

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Dominance is a description of the level of mastery of species of sample plots, so that the dominance value of a type can give an idea of the level of mastery of the species in a particular area (Kerry et al. 2017). Determination of the effect of the salt pond area on the dominance of mangrove species and predict whether experiencing outbreaks or decreases, a simple linear regression analysis was carried out.

The dominance of mangrove species in an area is influenced by environmental factors such as humidity, temperature, and the inability of a species to survive or lose the competition, such as the struggle for nutrients, sunlight, and growing space with other species that greatly affect the growth and diameter tree trunk. The dominant type has large productivity and the existence of the dominant species in the research location is an indicator that the community is in suitable habitat and supports its growth. In the type of mangrove that has a low dominance due to the high utilization of mangrove species, habitat or substrate that are not suitable, there is interaction between species or the inability of the type of mangrove to adapt to environmental conditions (Lignon et al. 2011; Hakim et al. 2017; Kusmana and Sukwika 2018).

The high diversity index value in Bipolo Village is due to the low land area and production of salt ponds so that the distribution of species is evenly distributed and no species dominates the area compared to Oeteta and Merdeka Villages where the area of land and production of salt ponds causes high species diversity due to land use or new land clearing which causes a decrease in species diversity in the region.

Diversity is a characteristic community that is related to the number of species or species richness and species abundance as community compilers. Community diversity is characterized by the many species of organisms that formed the community. Conversely, if the diversity of an environment is low, then the environment is susceptible to interference. So, in a community where high diversity will occur species interactions involving energy transfer, predation, competition, and more complex niches (Krebs 2009; Kerry et al. 2017).

Diversity index characterizes the level of community-based on its biology and community stability, namely the ability of a community to keep it stable even though there are disruptions to its components. In principle, the index value is higher, meaning that communities in the waters are increasingly diverse and are not dominated by one or more of the existing taxon. Diversity is an indicator of stability or stability of a growth environment. High diversity shows that a community has high complexity. Old and stable communities will have high species diversity. Whereas a community that is developing at the level of succession has a lower number of species than a community that has reached a climax (Hakim et al. 2017; Kusmana and Sukwika 2018; Utina et al. 2019).

The industry of salt ponds on the coast of Kupang Bay, especially around mangrove areas, indirectly affects the surrounding mangrove ecosystems and can reduce the quality of seawater around the mangrove area but for now, the area of land and the production of salt ponds have not had a significant influence on dominance or the index diversity of mangrove species because there is not too much land cultivated for salt pond activities.

This study found that salt pond area and salt pond production were positively correlated with the dominance of mangrove species, although the effect was not significant. On the other hand, salt pond area and salt pond production have a negative correlation with mangrove species diversity, although only salt pond area has a significant effect on mangrove species diversity. This shows that the impact of the development of the salt pond industry on the mangrove ecosystem in the short term can be detected from a decrease in mangrove species diversity, and in the long term it can also be detected from an increase in the dominance of mangrove species. This phenomenon can be applied in monitoring mangrove ecosystems related to the development of the salt pond industry, in an effort to conserve mangrove ecosystems in Kupang Bay.

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