Mangrove seedling abundance in mangrove ecosystem outgrowth in Ajkwa Island, Mimika Regency, Papua

R Sarwom*, Y Douw, K I Kusuma, D Operawiri, Y Y Heipon and A S Bahari

Reclamation, Biodiversity and Education, Environmental Department, PT. Freeport Indonesia, Mimika Regency, Papua

*Corresponding author e-mail: rsarwom@fmi.com

Abstract: Mangrove is one of the essential ecosystems for coastal areas. Mangrove is an individual or community which survives in tidal areas. Ajkwa Island is an island created by sedimentation activities from Ajkwa river. Ajkwa Island has a tidal supply well and it makes this island be an essential area for mangrove growth. This research was conducted in Ajkwa Island, Mimika Regency, Papua Province. The research is in permanent monitoring plots in 2011, 2014, and 2018. Based on the research, 2 categories were found in the monitoring plot, there are seedling and herbs. Species for seedling category are Avicennia marina, Bruguiera gymnorrhiza, Bruguiera cylindrica, Diospyros sp., Nypa fruticans, Sonneratia alba, and Xylocarpus sp. Species for herbs category are Allamanda cathartica and Hoya sp. Mangrove ecosystem type in Ajkwa Island is over-wash mangrove. The result, Sonneratia alba and Bruguiera gymnorrhiza had density and important value index higher than the other species in every monitoring year. Mangrove spreading in Ajkwa Island increases in each monitoring year. Mangrove seedling spread significantly from 2014 to 2018. On the monitoring plots, mangrove density in 2014 is 41,700 ind/ha and for 2018 is 74,000 ind/ha. Beside vegetation analysis, this research does spatial analysis to support the result from field monitoring data. Spatial analysis also proved the spreading of the seedling increased significantly from 2014 to 2018.

Keyword: Seedling, Density, Important value index, Spatial analysis.

1. Introduction

Mangrove is an individual or community which lives in a shoreline with high salinity and tidal tide adaptation mechanism. Mangrove is the one of “true trees” that can survive in tidal areas in tropical areas as a community or from the community itself [1]. South-east Asia had the highest mangrove diversity in the world [2]. There are 268 species of mangroves including 129 trees and herbs species, 28 liana species, 28 epiphyte’s, 23 fern’s, 7 palm, and 1 cycad. From 268 mangrove can found, 52 species are the true mangroves can live in tidal tide area and from spatial analysis, 55% mangrove ecosystem in Indonesia located in Papua [3].

Mangrove seedling is the second step for the mangrove reproduction process after fruit or weed from each individual mangrove. Seedling is one of the indicators that proved an area can be essential location for mangrove lives [4]. Mangrove seedling is the first process for mangrove grow, therefore this step is the one of the critical processes for mangrove growth to realize “walking tree” in mangrove life. Seedling will be growth be sapling and in the next step can be a tree. Seedling production would be affected if mature mangrove can’t produce the fruits or weed because the physical or ecological factors not essential.
Mangrove structure and composition can be affected by environmental conditions like organic carbon, salinity, type of the substrate and will be impacted to decomposition rate and nutrient availability inner substrate. Besides of that, mangrove species distribution can be affected how the species can spread and effected widely in ecosystem [5].

Ajkwa Island is one of island created by Ajkwa river sedimentation activity. Ajkwa Island that is the island can get tidal supply well and daily in the area and it can be an essential location where mangrove can grow well. Mangrove seedling have been an important factor for mangrove outgrowth in Ajkwa Island until now. New individuals can live naturally and be an important factor for ecosystem stability in Ajkwa Island.

Based on all, this research is to know how seedling can survive in Ajkwa Island and to know species composition to arrange in ground forest from Ajkwa Island. From this research hopefully our company or the other stakeholder can get a base data and base research for our regulation in the mangrove management system to raise the survival rate from each species in Ajkwa Island.

2. Study Site and Methods

This research is done in Akwa Island, Mimika Regency, Papua Province. Field data collection is in permanent plots and collected in 3 (three) periods in Juni 2011, April – November 2014, and May – June 2018. For spatial analysis and other data support for the research in January – June 2021 in Reclamation and Biodiversity Research Center, Environmental Department, PT. Freeport Indonesia.

Research location is a succession area from the natural process of sedimentation from Ajkwa River creating an island with completely mangrove composition. Data collection in the field continuously taken in the same plot to know mangrove seedling production and process of growth and get the data with high validity. Although we do the field monitoring, we also do spatial analysis to process seedling growth and spread in Ajkwa Island in each monitoring year.

For decision location of plot monitoring used purposive sampling method. Main object from monitoring is mangrove seedling and herbs in ground forest in monitoring plots. Monitoring method used plot sampling size 2 x 2 m as much as 25 repetition or plots. Our team tries to compare between seedling data existing in monitoring plots with spatial analysis each monitoring year.

This is the location map for data collection. Our map used the latest version in 2021 for spatial analysis (Figure 1).

![Figure 1. Mangrove seedling monitoring in Ajkwa Island.](image)
3. Results and Discussion
Based on field data analysis, 2 categories were found in monitoring plots are mangrove seedling and herbs. Mangrove seedling found are *Avicennia marina*, *Bruguiera gymnorrhiza*, *Bruguiera cylindrica*, *Diospyros* sp., *Nypa fruticans*, *Sonneratia alba*, and *Xylocarpus* sp. While the herbs found are *Allamanda cathartica* dan *Hoya* sp. Seedling is the first step for mangrove ecosystems to create coastline ecosystems. Seedlings existing are the seedlings that can survive with the environment condition in Ajkwa Island. From [6], In Mimika District were found 20 species of major mangrove, 10 species of minor component, and 36 species of mangrove associates. It can be a highly potential be seed or fruit resource in this area. Ajkwa Island is an island created by sedimentation process from Ajkwa river with a huge fresh water supply. Daily tidal tides can reach all the area from Ajkwa Island well. Type of the mangrove ecosystem in Ajkwa Island is over-wash mangrove.

| Species                  | Code | Density (Ind/ha) |
|--------------------------|------|------------------|
|                          |      | 2011  | 2014  | 2018  |
| *Allamanda cathartica*   | AC   | 0     | 500   | 0     |
| *Avicennia marina*       | AM   | 600   | 2600  | 22200 |
| *Bruguiera cylindrica*   | BC   | 2200  | 700   | 0     |
| *Bruguiera gymnorrhiza*  | BG   | 3400  | 10300 | 0     |
| *Diospyros* sp.          | DY   | 500   | 0     | 0     |
| *Hoya* sp.               | HY   | 0     | 0     | 100   |
| *Nypa fruticans*         | NF   | 100   | 3700  | 1500  |
| *Rhizophora apiculata*   | RA   | 3000  | 1600  | 10000 |
| *Rhizophora mucronate*   | RM   | 100   | 1600  | 1700  |
| *Sonneratia alba*        | SA   | 2700  | 20700 | 38400 |
| *Xylocarpus* sp.         | XY   | 0     | 0     | 100   |

**Figure 2.** Mangrove seedling density in Ajkwa Island on each monitoring year.

Based on Table 1 and Figure 2, we can see the growth rate in each species is different in each monitoring year. Like *Avicennia marina* and *Sonneratia alba* had significant different trends in each monitoring year. While for some species like *Rhizophora apiculata*, *Bruguiera gymnorrhiza* and *Nypa*
fruticans had different density values which fluctuated. Mangrove seedling density for Bruguiera gymnorrhiza always decreases in each monitoring year and disappears in 2018.

**Table 2.** Relative Frequency (FR), Relative Density (KR), Relative Dominance (DR), and Important Value Index (INP) each mangrove species in Ajkwa Island in each monitoring years.

| Year 2011 | | | | | | |
|---|---|---|---|---|---|---|
| No | Species | f | FR (%) | K (ind/ha) | KR (%) | BA (cm²) | DR (%) | INP (%) |
| 1 | Bruguiera gymnorrhiza | 0.64 | 30.77 | 3.400 | 26.98 | 88.59 | 39.44 | 97.19 |
| 2 | Rhizophora apiculata | 0.28 | 13.46 | 3.000 | 23.81 | 77.71 | 34.59 | 71.86 |
| 3 | Sonneratia alba | 0.60 | 28.85 | 2.700 | 21.43 | 9.82 | 4.37 | 54.65 |
| 4 | Bruguiera cylindrica | 0.12 | 5.77 | 2.200 | 17.46 | 38.59 | 17.18 | 40.41 |
| 5 | Diospyros sp. | 0.20 | 9.62 | 500 | 3.97 | 6.70 | 2.98 | 16.57 |
| 6 | Avicennia marina | 0.16 | 7.69 | 600 | 4.76 | 2.44 | 1.09 | 13.54 |
| 7 | Rhizophora mucronata | 0.04 | 1.92 | 100 | 0.79 | 0.79 | 0.35 | 3.07 |
| 8 | Nypa fruticans | 0.04 | 1.92 | 100 | 0.79 | 0.00 | 0.00 | 2.72 |
| Total | | | | 2.08 | 100 | 12.600 | 100 | 224.64 | 100 | 300 |

**YEAR 2014**

| | | | | | | |
|---|---|---|---|---|---|---|
| 1 | Sonneratia alba | 0.68 | 19.32 | 20.700 | 49.64 | 3.20 | 16.67 | 85.63 |
| 2 | Bruguiera gymnorrhiza | 0.96 | 27.27 | 10.300 | 24.70 | 6.20 | 32.29 | 84.26 |
| 3 | Nypa fruticans | 0.60 | 17.05 | 2.700 | 8.87 | 3.60 | 18.75 | 44.67 |
| 4 | Rhizophora mucronata | 0.36 | 10.23 | 1.600 | 3.84 | 1.80 | 9.38 | 23.44 |
| 5 | Avicennia marina | 0.28 | 7.95 | 2.600 | 6.24 | 1.20 | 6.25 | 20.44 |
| 6 | Rhizophora apiculata | 0.28 | 7.95 | 1.600 | 3.84 | 1.40 | 7.29 | 19.08 |
| 7 | Bruguiera cylindrica | 0.20 | 5.68 | 700 | 1.68 | 1.00 | 5.21 | 12.57 |
| 8 | Allamanda cathartica | 0.16 | 4.55 | 500 | 1.20 | 0.80 | 4.17 | 9.91 |
| Total | | | | 3.52 | 100 | 41.700 | 100 | 19.20 | 100 | 300 |

**YEAR 2018**

| | | | | | | |
|---|---|---|---|---|---|---|
| 1 | Sonneratia alba | 0.76 | 27.14 | 38.400 | 51.89 | 3.80 | 27.14 | 106.18 |
| 2 | Avicennia marina | 0.64 | 22.86 | 22.200 | 30.00 | 3.20 | 22.86 | 75.71 |
| 3 | Rhizophora apiculata | 0.60 | 21.43 | 10.000 | 13.51 | 3.00 | 21.43 | 56.37 |
| 4 | Nypa fruticans | 0.48 | 17.14 | 1.500 | 2.03 | 2.40 | 17.14 | 36.31 |
| 5 | Rhizophora mucronata | 0.24 | 8.57 | 1.700 | 2.30 | 1.20 | 8.57 | 19.44 |
| 6 | Xylocarpus sp. | 0.04 | 1.43 | 100 | 0.14 | 0.20 | 1.43 | 2.99 |
| 7 | Hoya sp. | 0.04 | 1.43 | 100 | 0.14 | 0.20 | 1.43 | 2.99 |
| Total | | | | 2.80 | 100 | 74.000 | 100 | 14.00 | 100 | 300 |
Table 3. Diversity Index (H') and Uniformity Index (J') of mangrove seedling in monitoring station in Ajkwa Island.

| Year | H'   | Category | J'   | Category |
|------|------|----------|------|----------|
| 2011 | 0.73 | Low      | 0.08 | Low      |
| 2014 | 0.63 | Low      | 0.06 | Low      |
| 2018 | 1.81 | Low      | 0.16 | Low      |

Based on density data and spatial analysis results in Figure 3, the result is that mangrove seedlings can spread well in Ajkwa Island and rise-up in every monitoring year. The density significantly rise-up from 2014 to 2018. In monitoring plots only, total density value mangrove seedling from 2014 is 41,700 ind/ha and for 2018 is 74,000 ind/ha. From [7] leaf growth rate from Xylocarpus moluccensis is slower than Rhizophora apiculata and Bruguiera gymnorrhiza. First leaf of Rhizophora apiculata can arise in day 21 until 38 and for Bruguiera gymnorrhiza can arise in day 29 until 49 after propagule reached the substrate and for Xylocarpus moluccensis can arise the first leaf from fruit in day 45 until 65 after reached the substrate. Therefore, Sonneratia alba is the species that can spread widely and significantly in Ajkwa Island in each monitoring year. Suggestion from [7] analysis, Sonneratia alba is the one species mangrove can grow the first leaf faster than the other species of mangroves.

Look from spatial analysis (Figure 3) from 2012 and 2014, not to contrast for the spread of the mangroves. However, in 2019 mangrove in Ajkwa Island spread widely and mangrove seedling can occupy all the areas. Pioneer plants produce abundant biomass that add and increased an essential carbon base in the soil [8]. Environmental condition from Ajkwa Island is the support of mangrove spread and living well. Sedimentation process is one of natural processes to provide new land for mangrove reproduction. Ajkwa Island can prove the “walking forest” theory and can increase the progress for mangrove spreading. Mangrove can live and spread well by river stream or tidal tide carrying the propagule or mangrove fruit to new open area or mudflat. More than 1.4 million hectares mangrove in Papua is the vast and undisturbed forest, making it the one of the largest mangrove forest in the world [9], and hopefully seedling in Ajkwa Island can grow well like the other mangrove forest in Papua.

This can be an exciting result and can be a research background for companies or stakeholders to create a policy about mangrove management and planning in Ajkwa Island or this island’s area. Mangrove seedling found in this research can be a scientific reason to choose a species in rehabilitation programs from Ajkwa Island or the other area near by this island. Sonneratia alba and Bruguiera gymnorrhiza, both of species are dominance species from Ajkwa Island based on this research in monitoring plots. Both species are pioneer species in Ajkwa Island and can be a good choice in the reclamation and rehabilitation program. Based on density data, it can be special notes for companies or stakeholders that the island can get supply the seed or fruits from mature mangrove well. It can prove the mature mangrove can produce and fill the demand of the seedling in Ajkwa Island and mature mangrove can grow well in this island or the other area. With high production of mangrove fruit and propagules, it can raise the survival rate of the mangrove in Ajkwa Island, although each species can choose the preferable location for life.

Sonneratia alba and Bruguiera gymnorrhiza are a package for mangrove reclamation and rehabilitation process in Ajkwa Island. Sonneratia alba is one of mangrove pioneer for mangrove spreading in the Island. After this species growth well and be a mature mangrove, Bruguiera gymnorrhiza be a second layer and live in filled the open space area in Ajkwa Island ground forest with low light intensity. Moreover, both species are major species and have different functions for the mangrove ecosystem in Ajkwa Island.
Figure 3. Landscape transformation mangrove ecosystem in Ajkw Island from 2012 to 2019. (a) Mangrove existing on 2012; (b) Mangrove existing on 2014; (c) Mangrove existing on 2019.
4. Conclusion
Mangrove seedling in Ajkwa Island is still spreading for each monitoring year. It is in line with the expansive new area in Ajkwa Island. The area from the mangrove ecosystem rises for every monitoring year. Environmental conditions are an excellent factor for mangroves to spread widely and keep the regeneration progress for mangroves in Ajkwa Island. As a managerial aspect, stakeholders, government, and company can propose *Sonneratia alba* and *Bruguiera gymnorrhiza* be an optional species for rehabilitation mangrove program in Ajkwa Island.

Acknowledgments
The author would like to acknowledge Reclamation, Biodiversity and Education team Environmental Department, PT. Freeport Indonesia for all support and contribution in this research.

References
[1] Tomlinson P B 1994 *The Botany of Mangroves* (New York: Cambridge University Press)
[2] Giesen W, and Wulffraat S 1998 *Tropical Biodiversity* 5(2) 11-23
[3] Giesen, W, Wulffraat, S, Zieren M, Scholten L 2007 *Mangrove Guidebook for Southeast Asia* (Bangkok: FAO Regional Office for Asia and the Pacific)
[4] Pribadi R, Dharmawan I W E and Bahari A S 2020 *Majalah Ilmiah Biologi Biosfera: A Scientific Journal* 37(2) 106-111
[5] Hastuti E D, Hartuti and Rini B 2018 *IOP Conf. Ser.: Earth and Environ. Sci.* 130 012015.
[6] Setyadi G, Pribadi R, Wijayanti D P and Sugianto D N 2021 *Biodiversitas* 22(8) 3562 – 3570
[7] Tolangara A, Tuaputty H and Corebima, A.D 2015 *Donnish Journal of Research in Environmental Studies* 2(1) 1 – 4
[8] Puradyatmika P, Prewitt J M 2012 *Australian Center for Geomechanics* 173 – 186
[9] Setyadi G, Rahayu D L, Pribadi R, Hartati R, Wijayanti D P, Sugianto D N and Darmawan A 2021 *Biodiversitas* 22(10) 4146 – 4157