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Research Article

Tree Species Diversity of Mangrove at Tunku Abdul Rahman Park, Sabah Malaysia

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Abstract

Mangrove area could be found at Kota Kinabalu area which include the Tunku Abdul Rahman Park, Sabah. The Tunku Abdul Rahman Park were gazette as Sabah second National Park in 1974. This shows that how important mangrove area as parts of the habitat found in the Tunku Abdul Rahman Park, Sabah. The aim of the study is to determine the man-grove tree species diversity, the distribution of mangrove tree stand structure and identifying factors that relates with man-grove species diversity at Manukan and Gaya Island at Tunku Abdul Rahman Park, Sabah. There are four plots; one at Manukan Island and three at Gaya Island with the size of 30m x 20m to measure the number of species individuals, diameter breast height (dbh) and height at the study site. Plus, diversity indices such as Shannon-Weiner Diversity Index (H'), Shannon Evenness (E), and Simpson's Index Diversity (1-D) would be calculated. Besides, ecological factors influencing the diversity of mangroves such as percentage of organic matter con-tent, present of predator and pH of water plus soil would be taken and analyzed. From the result, the indices for Gaya Island are H'=0.72, E=0.33 and 1-D=0.33 while for Manukan Island are 0 for all indices. This shows that Gaya Island is more diverse than Manukan Island but in general, both of them can be considered as less diverse. As for the ecological factors, Gaya Island shows ranges resulted in area suitable for almost all mangroves species, while for Manukan Island, the ranges for one species which is *Bruguiera hainesii*. Hence, it shows that every mangrove species has different preferences of ecological factors which resulted in the diversity of mangrove species composition in an area. Plus, from the data collected, proper action from the management could be made for the mangroves area at Tunku Abdul Rahman Park and become one of the attractions for tourist plus to avoid the mangroves species to extinct.

Keywords: Mangrove; Ecological Factors; Species Diversity; Tunku Abdul Rah-man Park

Introduction

Mangrove forest could be found along the tidal mudflats and along the area of coastal shallow water which extend-ed upwards towards the land along the brackish water, streams and the headwater of the river [1]. Mangrove could be found at the intertidal zone where the water will be covering the mangrove during high tide and exposing the mangrove during low tide. Mangrove generally could be found within the coastal tropical and subtropical climate. Some of the mangrove have expanded and have been found at some temperate location [2,3].

The word "mangrove" has been used to refer either to the constituent plants of tropical intertidal communities or to the community of the mangrove itself [4]. The mangrove forest consists of: (i) true mangrove and the (ii) associate mangrove [5]. The most abundance distribution of mangrove species is the Rhizophora's genus which is also highly dominant throughout the Peninsula Malaysia and the Borneo island of Malaysia. Tunku Abdul Rahman Park, which is located off Kota Kinabalu, Sabah was established as state park in 1974 and expanded in 1979 consisting of Pulau Gaya, Pulau Sapi, Pulau Manukan, Pulau Mamutik and Pulau Sulung; which an area about 4,929 hectare under the jurisdiction of Sa-bah Parks. The Sabah Park has designed an ordinance which aims to protect the environment of the island and its surrounding waters especially the coral reefs from human exploitation. In some parts of Gaya and Manukan Island, mangrove could be found around the islands.

Mangroves have adaptations towards their environ-ment. Their biological and morphological adaptation such as the shoot system, the root system, biogeography and salt water balance makes mangrove stand out more than other plants [6]. The establishments of the seedlings are critical in the mangrove life cycle due to the unstable condition of the environment, variable substrate and the tidal influence inside the mangrove environment [4]. This shows

that mangrove is still vulnerable despite having unique adaptation towards its environment.

Mangrove serves as a nursery ground for juvenile vertebrates, invertebrates and crustacean [7]. Mangrove also provides good sources of woods and timber for housing materials and firewood or charcoal [8]. Overexploitation from human may occur in many industries such as aquaculture, housing develop-ment, tourism and raw materials [9]. These cause a major depletion towards the mangrove abundance and mangrove species. Plus, global warming makes it hard for the mangrove to survive. Besides, the natural occurrences like Tsunami bring huge impact to-wards the mangrove depletion, but such occurrences do not happened often.

The objectives of my studies are (i) to identify the diversity of mangrove that related to the factors such as soil, pH and predator towards the mangrove species in mangrove area at Manukan Island and Gaya Island, and (ii) to analyze the distribution of mangrove tree stand structure based on tree diameter of breast height (DBH), height and regeneration and Manukan Island and Gaya Island.

Methodology

Study area: The study was conducted in mangrove area of Manukan and Gaya Island at Tunku Abdul Rahman Park, Sabah. There are four plots with 30m x 20m quadrant; one plot at Manukan Island and three plots at Gaya Island. The location for four plots was point using Global Positioning System (GPS) at figure 1 below.

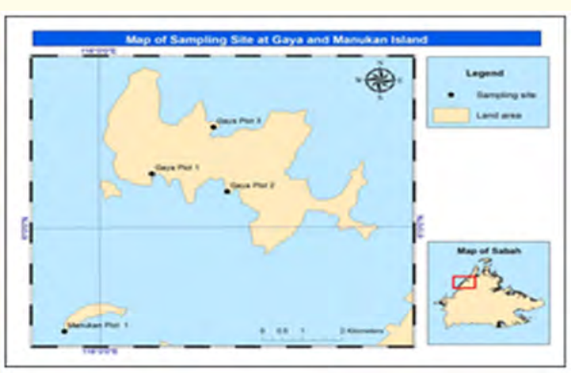

Figure 1: The location for plots area at Manukan and Gaya Island.

Sampling method

According to Hamid [10], there is few sampling method being use in this study. The first method was to take the measurement of mangroves that includes the (i) species frequency of the mangroves, (ii) the height using Suunto Klinometer and Trimble in percentage (%), (iii) the diameter breast height (dbh) by using diameter tape measuring around the bark at 1.3 m point of a tree from the ground and (iv) sapling frequency; sapling means tree that has diameter breast height (dbh) less that 10cm but more than 1cm. The formula for height was listed below:

Measured tree height by percentage (%);

Height= [(((x%+ ±y%)/100)×d)]+h

d = Distant of the tree with the eyes (meter)

h = Height of the measuring person (meter)

%= Percentage of tree height

Next, the ecological data taken was (i) soil sample for surface and 30cm depth using small shovel for further analysis of organic matter content using loss of ignition (LOI) method and soil pH using the 1:2.5 soil to water ratio were made and using pH meter to get the value of pH soil [11], (ii) pH of seawater was taken at each plot using multi parameter and (iii) predator found in each plots at the mangrove area.

Data analysis: The data taken on the sampling method would be further analyzed. The measurement of mangrove would be analyses into two parts; (1) distribution of man-grove species by measuring the average diameter and height plus their correlation and; (2) the diversity indices using three indices; (i) Shannon-Weiner Diversity Index (H') to measure the variation of species at each plot with 0 being, (ii) Shannon Evenness Index (E) to measure the maximum diversity that would occur can be found and (iii) Simpson's Diversity Index (1-D) that quantify the biodiversity of a habitat while being less sensitive towards species richness. The formulas for diversity indices are described below:

Shannon-Weiner Diversity Index (H')

$H'=-\sum[Pi \ln Pi]$

Pi= Number of individual found in i-th species

ln= Natural logarithm of pi

Shannon Evenness Index (E)

$E= H'/\ln S$

S= Number of species present

Simpson's Diversity Index (1-D)

$1-D=(\sum(n(n-1))/(N(N-1))$

n= Total number of organism of a particular species

N= Total number of organism of all species

Results and Discussion

Mangrove species composition distribution

The number of mangrove species found at both islands; Manukan and Gaya was two and 91 individual of species respectively. For Manukan Island there were only two individuals of *Bruguiera hainesii* while for Gaya Island there were 91 frequency of species found which composite of *Avicennia officinal, Bruguiera cylindrical, Heritiera littoralis, Lumnitzera littorea, Lumnitzera racemosa, Rhi-zophora apiculata, Scyphiphora hydrophyllacea,* and Xylocar*pus*

moluccensis with *Rhizophora apiculata* being the highest frequency of 67 individuals found (Figure 2). Based on Hogarth [12], different species of mangroves found at the study area are not scattered randomly, but in discrete and monospecific zones shows at Manukan and Gaya Is-land. In this case, species occurs at designated plotted area are the subsets of the species present for the whole area which was Manukan, Gaya Island or Tunku Abdul Rah-man Park Sabah as a whole.

The species found in Manukan Island was *Bruguiera hainesii* also known as Berus mata buaya. There are two adult mangrove tree and 16 sapling found at the cape of Manukan Island. This species is a critically endangered species based on the International Union for Conservation of Nature Resources (IUCN) [13] due to low rates of propagation and germination which lead to at least 27% loss of mangrove area with this species from the year 1980 and 2005 [14].

Gaya Island has more variation of species except the *Bruguiera hainesii*. The most dominated species found in plots at Gaya Island are *Rhizophora apiculata* in the family Rhizophoraceae. Based on the International Union for Conservation of Nature Resources (IUCN) [15], this species is the least concerned in their scale. Other species which was found have lesser frequency than *Rhizophora apiculata* but, the occupying Gaya Island.

For the factors that affect the mangrove species distribution composition, the geographical distribution for *Bruguiera hainesii* is very limited and patchy which do available in Singapore, Malaysia and Papua New Guinea. Plus, for *Rhizophora apiculata* the species usually found around the south Asia including Malaysia. Hence, making these two species survive in tropical area. For the other species found, their distributions are mostly the same as for *Rhizophora apiculata*. Plus for Gaya Island, the man-groves area are small patchy in between crevices.

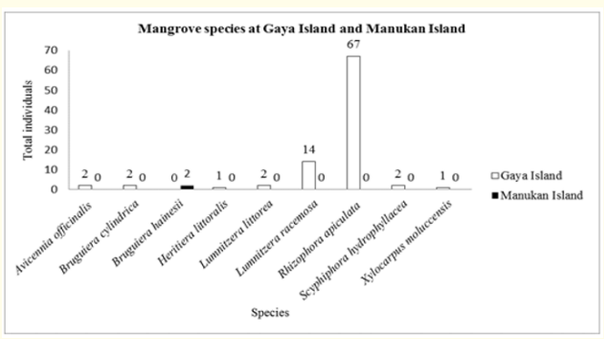

Figure 2: Number of mangrove species found at both islands; Manukan and Gaya Island.

For the sapling frequency, there are eight species found in both islands consist of 16 individuals of *Bruguiera hainesii* found at Manukan Island and 298 individuals found at Gaya Island which consist of *Avicennia officinal, Bruguiera cylindrical, Lumnitzera littorea, Lumnitzera racemosa, Rhizophora apiculata, Scyphiphora hydrophyllace and Sonneratia alba* with *Rhizophora apiculata* having the highest species frequency of 249 individuals found (Figure 3).

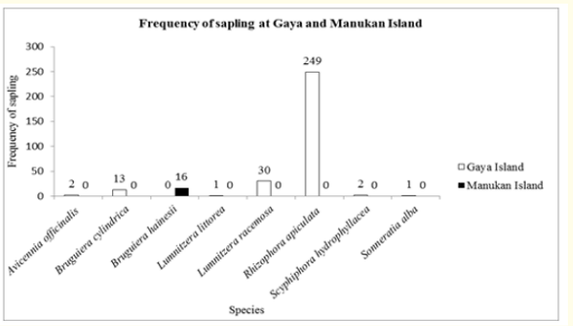

Figure 3: Frequency of mangrove sapling species at both islands; Manukan and Gaya Island.

Diameter and height distribution of mangrove species

For the diameter breast height (dbh) of mangrove at Manukan Island, there are only two individuals of *Bruguiera hainesii* with total individuals of two and total dbh of 102.3cm plus average dbh of 51.2cm. Plus, it is hard to get the relation between mangrove dbh (cm) and its individuals, but not at Gaya Island. Based on Figure 4, in Gaya Island the most dominant tree diameter was at dbh class 10-15 cm with 51 individuals, 16-20 cm with 22 individuals, 21-25 cm with seven individuals, 26-30 with six individuals, 31-35 with two individuals, 36-40 cm, 41-55 cm with one individual each, 51-55 cm with zero individual and 56-60 cm with one individual (Figure 4).

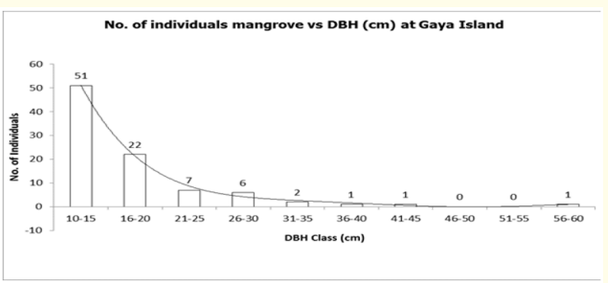

Figure 4: Relation between mangroves dbh (cm) with the number of mangrove individuals at Gaya Island.

From the data of average dbh (cm) at Gaya Island, relation between the dbh (cm) and number of mangrove individuals were made into graph which shows that an inverted J –curve which shows that a normal uniform tree age of mangroves at Gaya Island (Figure 4). In Tunku Abdul Rahman Park, most of the mangrove species are for tourism purposes [16]. Hence, no further destruction of the mangroves area such as local dependency for timber or firewood because Manukan and Gaya Island are in Tunku Abdul Rahman Park which was one of the marine protected areas in Sabah.

For the height of mangrove at Manukan Island, there are only two individuals of *Bruguiera hainesii* with total individuals of two and total height of 22.60m plus average height of 11.30m. Due to fewer individuals, the relation between the height and mangroves' individuals could not be done. For mangrove at Gaya Island, the relation between mangrove heights (m) with the number of mangrove individuals, the height class and the number of mangrove individuals were 2.00-2.99m with 34 individuals, 3.00-3.99m with 29 individuals, 4.00-4.99m with 13 individuals, 5.00-5.99m with eight individuals, 6.00-6.99m with zero individuals, 7.00-7.99m with four individuals, 8.00-8.99m with one in-dividual and 9.00-9.99m with two individuals (Figure 5).

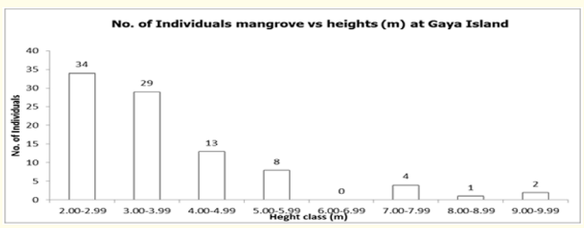

Figure 5: Relation between mangrove heights (m) with the mangrove individuals at Gaya Island.

Plus, from Figure 5, the graph shows a normal curve which shows the distinctive height for mangrove individuals at Gaya Island from the data, it does shows that Manukan Island's mangrove has higher average compared with Gaya Islands' due to the location of the mangrove area plotted. Manukan Island was at the cape of the island which had direct sunlight in all direction while for Gaya Island, not all the mangrove tree receives enough sunlight due to sur-rounding flora.

From both of the information; height and dbh, we could find a correlation of growth and distribution of mangroves at Gaya Island. As for Manukan Island, there are not enough data to make such correlation. From Figure 6, it shows that the mangrove individual cluster at ranges from 10.0cm to 20.0cm and 2.00m to 5.00m which does indicate a normal distribution of mangrove species.

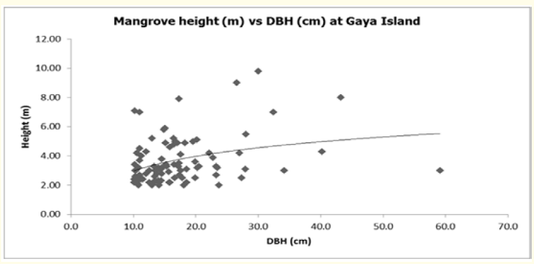

Figure 6: Distribution of mangrove heights (m) and dbh (cm) at Gaya Island.

Diversity indices

From the data recorded, the mangrove diversity indices at both islands was for the Shannon-Weiner (H') at Manukan and Gaya Island with H'= 0 and H'= 0.72 respectively. Next, the Shannon Evenness (E) at Manukan and Gaya Island with E= 0 and E= 0.33 respectively. Besides, the Simpson's Diversity Index (1-D) at Manukan and Gaya Island with 1-D= 0 and 1-D= 0.33 respectively.

According to Magurran [17], the higher the value of H', the higher the diversity of the area studied. The value for both does not in the normal ranges of 1.5 to 3.5 and rarely surpasses 4 [18] which lesser than the normal ranges. This could conclude that even though Gaya Island has higher H' value than Manukan Island, both of them are still less diverse. Plus, the value of Shannon Evenness (E) range between 0 and 1 with 1 being very equally diverse whic again shows that Gaya Island has higher evenness than Manukan Island. The Simpson's Index Diversity (1-D) shows the value of the area diversity. The value ranges be-tween 0 and 1 with the approach of the greater the value of (1-D), the greater the diversity of the studied area which means that Gaya Island are more diverse compared to Manukan Island.

Ecological factors

pH of seawater

For the ecological factors, the pH value of seawater at Manukan Island is pH 8.04, while Gaya Island ranges from pH 8.01 to pH 8.12. This shows that the pH between two islands; Manukan and Gaya Island does not varied much and still within the normal seawater ranges between 7.5 and 8.4 but have the average of 8.0 which is slightly alkaline [19]. The pH and salinity gradient are usually correlate with one another and there are not much of studies comprising about the pH value of seawater and mangroves species.

pH of soil and organic matter content

The soil samples were taken at the surface and 30cm depth at each plot for both islands to be further analyse for the pH of soil and organic matter content. For the soil pH at Manukan Island, was pH 8.05 for surface and pH 8.35 for the 30cm depth. As for

the Gaya Island, the ranges was between pH 6.91 and pH 7.87 for surface and pH 7.17 and pH 7.86 for the 30cm depth of soil sample. this does shows that species at Manukan Island, *Bruguiera hainesii* more prone to slightly alkaline soil while other mangroves species at Gaya Island prefer more neutral to slightly acidic soil pH.

Usually, the acidity levels of soil tend to increase with depth because the surface soil is mostly consisting of de-composes fibrous roots of mangrove that produce sulphides which is acidic [20]. Lower acidity level may due to salinity and moderate inundation. *Bruguiera hainesii* species found at Manukan Island does not seem to follow Simpson and Pedini [20] but, mangrove species itself strive at their own environment with lots of variation in every aspect. This could also explain why there is only Bruguiera hainesii found at Manukan Island and not at any plots at Gaya Island.

The value of soil pH changes between mangrove species because it regulates the availability of nutrient in the soil. They need macronutrients and micronutrient such as nitro-gen, phosphorus, iron manganese and zinc [11]. Plus, plant nutrients in the soil contribute to organic matter content which affects the availability of nitrogen phosphorus, calcium, and potassium of the plants [21].

The organic matter content was analysed using the loss of ignition method. The percentage of organic matter content found in Manukan Island was 1.73% for surface and 1.70% for 30cm depth. For Gaya Island, the ranges for percentage of organic matter content for surface was between 0.83% and 1.11% while for 30cm depth was between 0.91% and 1.25%.

Organic matter content for soil at 30cm depth has higher percentage of organic matter compared with surface soil. This statement is ideal for Gaya Island with surface organic matter content in between ranges of 0.83% to 1.11% and 30cm depth with ranges between 0.91% and 1.25%. This is because during sieving the soil sample, there are lots of non-decompose roots, leaf litter and shell was found. This phenomenon occurs due to the tidal imports and leaf litter at the mangrove area and still waterlogged of the soil [22]. Other reason was decomposition process is slower in anaerobic area due to oxygen limited area such as the mangroves area like Gaya Island [23].

As for Manukan Island, the organic matter content at surface is 1.73% and for 30cm depth is 1.70%. The organic matter content is higher than Gaya Island itself which shows that *Bruguiera hainesii* do prefer high organic matter con-tent environment but a slight decrease for organic matter content of 30cm depth. This also shows another reason why *Bruguiera hainesii* could only be found at Manukan Island and not at Gaya Island.

Predators

As for the predators found, there was ants and gastropods found at both islands. Based on the data collected, the total of predator found was 168 predator species compose of *Formicidae spp., Terebralia sulcata, Ellobium sp. and Littoraria sp.* Manukan Island, there was 25 species of predator composed of *Formicidae spp., Terebralia sulcata and Littoraria sp*. while for Gaya Island, there was 80 species composed of all four predators. There are also said that proboscis monkey and normal monkey could be found around the mangrove area at Gaya Island.

Most of the predator at mangroves area does not only bring mortality towards the mangrove tree itself but more of a mutualism relationship. Several studies had found that seedling mortality of mangroves does occur by crabs, snails or insects [24]. One of the species found at all plots for both islands; Manukan and Gaya Island is ants. According to Hogarth [11], ants are abundant in man-groves trees especially in canopy which suggest their ecological importance towards the mangrove area. They mostly found following a trail on the mangrove branches and essentially a terrestrial animal, hence it is not a surprise to found ants at mangroves area. Their presence does significantly decrease the number of herbivores insects by leaving pheromones marks on the mangrove leaves which reduce the leaves damage.

Next, snails are the most noticeable mollusks from each plots of both island. Again, based on Hogarth [11], very few snails are exclusive to mangroves area. In Manukan Island there are two snails species found which are *Terebralia sulcata* and *Littoraria sp.* while in Gaya Island, there are three snails found which are *Terebralia sulcata, Littoraria sp* and *Ellobium sp.* Most of these snails are deposit feeders and found at the mangrove barks or on the ground. Few of these gastropods east mangroves leaf and have more of mutualism relationship which shows for *Terebralia sp.* that has a major role in removing leaf litter and retaining mangrove production within the mangrove area.

Other predators found but did not shows in the result is monkey [25]. According to Hogarth [11], monkeys are common in mangroves area but these animals bring damage towards the mangrove replanting project. Some of the monkeys are exclusively herbivorous which is called proboscis monkey (Nasalis Larvatus) which could only be found in Borneo and restricted to mangroves and riverine forest. They consume the mangroves leaves as one of their diet. These could be justified by Christopher Yaspin [25] and Nasrulhakim Maidin [26].

Conclusion

Based on the data gathered, there are 11 species found at both islands; one at Manukan Island and ten at Gaya Island. Based on the diversity indices, Gaya Island is more diverse in terms of mangrove species and individuals than Gaya Island, but overall does not in the normal ranges. For the seawater pH for both islands are still in the range for seawater. The soil pH and organic matter content composition, Gaya Island has the most preferable soil for most of the species recorded with neutral to slightly acidic soil pH while

Manukan Island's mangrove prefer slightly alkaline soil. For organic matter content percentage for Manukan Island is higher than Gaya Island which shows that *Bruguiera hainesii* species preferred abundant of nutrient. The predators found are ants and snails which have mutualism relationship with the mangrove area, plus monkeys and proboscis monkey due make mangrove area as one of their habitat and diet.

Some recommendation that could be done for further study is by increasing the number of plot study at Tunku Abdul Rahman Park because the mangroves area are small and patchy. This could gather data for more accurate value of diversity indices. Plus, more ecological data which affecting mangroves should be gathered such as tidal ranges, salinity gradient and carbon content to gain more knowledge about the mangrove area around Tunku Abdul Rahman Park which could open new opportunities in eco-tourism in Sabah.

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Bibliography

1. Baleta N. F. and Ronald S. C. 2016. Species Composition, Diversity and Abundance of Mangrove Along the Estuarine Area of Maligaya, Palanan, Isabela, Philiphines. Isabela, Philiphines.

2. Owers CJ, Rogers K, Woodroffe CD. 2018. Spatial variation of above-ground carbon storage in temperate coastal wetlands Estuarine. Coastal and Shelf Science 210:55-67.

3. Krauss W. K., Catherine E. L., Karen L. McK., Laura L. H., Sharon M.L. E., Wayne P. S. 2008. Environmental Drives in Mangrove Establishment and Early Development: A review". Lafayette, Louisiana, United State America.

4. Tomlinson P. B. 1986. The Botany of Mangrove. Cambridge University Press, Cambridge. S. M. Metev and V. P. Veiko, Laser Assisted Microtechnology, 2nd ed., R. M. Osgood, Jr., Ed. Berlin, Germany: Springer-Verlag, 1998.

5. Susilo, H., Takahashi, Y., & Yabe, M. 2017. Evidence for Mangrove Restoration in the Mahakam Delta, Indonesia, Based on Households' Willingness to Pay. Journal of Agricultural Science, 9(3), 30.

6. Ellison, J.C. 2019. Biogeomorphology of mangroves. In Coastal Wetlands: An Ecosystem Integrated Approach; In Wolanski, E., Cahoon, D., Perillo, G.M.E., Eds.; Elsevier Science: Amsterdam, The Netherlands 2018,

7. Mojiol, A.R., Guntabid, J., Lintangan, W., Ismenyah, M., Kodoh, J., Liew, K.C & Sompud, J.,. Contribution of Mangrove Forest and Socio-Economic Development of Local Communities In Kudat District, Sabah Malaysia". International Journal of Agriculture, Forestry and Plantation, 2 (2016a).

8. Polgar G and Jaafar Z. 2018. Endangered forested wetlands of Sundaland: ecology, connectivity, conservation. In: Polgar G, Jaafar Z (eds) Ecotourism and the future of the forested wet-lands of Sunsaland. Springer, Switzerland, pp 89-93

9. Mojiol, A.R., Kodoh, J., Wahab, R., Majuki, M and Wahyudi.. Contribution of non-wood forest product to the local community living near mangrove forest in Kudat, Sabah. Journal of Tropical Resources and Sustainable Sciences, 4 (2016b): 38-41. ISSN 2462-2389

10. Hamid MIA. Hutan: Pengurusan dan Penilaian. Dewan bahasa dan Pustaka. Kuala Lumpur, Malaysia (1998).

11. Joshi H and Ghose M. 2003. Forest Structure and Species Distribution along Soil Salinity and pH Gradient in Mangrove Swamps of the Sundarbans. International Society for Tropical Ecology 44(2).

12. Hogarth PJ. The Biology of Mangroves and Seagrasses. 3rd Ed. Oxford University Press, United Kingdom (2015).

13. International Union for Conservation of Nature Resources (IUCN). Bruguiera hainesii (2010).

14. FAO. 2007. The World's Mangroves 1980-2005. FAO Forestry Paper 153. Forestry Department, Food and Agriculture Organization of the United Nations (FAO), Rome.

15. International Union for Conservation of Nature Resources (IUCN). Rhizophora apiculate (2010).

16. Matasan Ismail. Personal Communication (2017).

17. Magurran AE. Measuring Biology Diversity, Blackwell Science Ltd, United Kingdom (2004).

18. Margalef R. 1972. Homage to Evelyn Hutchinson, or why is there an upper limit to diversity? Trans. Connect. Acad. Arts Sci. 44, 211-253.

19. Garrison T. 2013. Oceanography: An Invitation to Marine Science. 8th ed. pp 219-222 Brooks/Cole, Cengage Learning, USA.

20. Simpson H. J. and Pedini M. 1985. Brakish Water Aquaculture in the Tropics. The Problems of Acids Sulphate Soils. FAO Fisheries Circular 791: p32.

21. Effiong G. S. and Ayolagha G. A. 2010. Charactheristic, Constrains and Management of Mangrove Soils for Sustaina-ble Crop Production. EJEAF Che, 9(6). P977-990.

22. Moorman F. R. and Pons L. 1974. Characteristics of Mangrove Soils in Relation to Their Agriculture Land Use and Potential. In Proc. Int. Symp. Biology and Management of Mangroves. Gainesville: Institute of Food and Agriculture Sciences, University of Florida, Florida. pp548 - 560.

23. Ponnamperuma F. N. 1972. The Chemistry of Submerged Soil. Adv. Argon 24. P96.

24. Robertson A. I., Giddins R. and Smith TJ III. 1990. Seed Predation in Tropical Mangrove Forest: Extend and Effect on Seed Viability and the Growth of Seedlings. Oecologia. 83: pp213-219.

25. Christopher Yaspin. Personal Communication (2017).

26. Nasrulhakim Maidin Personal Communication, April 3, 2017.

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