Characteristics and Above-Ground Biomass of Mangrove Species in Enggano Island, Bengkulu Sumatra, Indonesia

Mohammed Sadeq Mohammed Awn[1], Fredinan Yulianda[2], Yonvitner[3]

[1]Student of Study Program of Coastal and Marine Management, Graduated School of Bogor Agriculture, Indonesia
[2,3]Department Aquatic Resources Management Faculty of Fisheries and Marine Science (FFMS-BAU), Indonesia

Abstract— *Estimation of biomass mangrove vegetation plays a vital role in the evaluation of nutrient turnover and potential to act as a carbon sink. Preliminary investigations show that inadequate studies have been conducted on a characterization of mangrove forest. Therefore, the aim of this study is to identify species, characterization andaboveground biomass of mangrove vegetation in the Enggano Bengkulu Island of Sumatra, Indonesia. To implement this, the quadrant transect method is applied. The data are collected at 10 m^2 quadrat random sampling points along seven stations laid perpendicular to the shoreline. From the experiment, the results show that coverage density of R. apiculata, B. gymnorrhiza, Sonneratia alba, and X. granatum, 63%, 27%, 6% and 4.6% respectively. R. apiculata had the highest values of X. granatum having the lowest. From the data analysis showed linearly increased with an increase of basal area, aboveground biomass was strongly related to the basal area in mangrove forests as results of correlation r = 0,9454 in an equation of Y=1, 7025x-3,6276, with R^2 = 8938. When BA increase 1 m^2/ha, the biomass increased by 1.7025 ton/ha. The average values for the basal area, estimation based on biomass, B. gymnorrhiza present the highest, at 22 m^2/ha, 41,30 t/ha with X. granatum 2,5 m^2/ha, 3.95 t/ha lowest. From the findings, it is depicted that there is a significant indirect effect of a change of characteristic of mangrove forest due to human encroachment evidence by the reduction in X. granatum and S. alba species population, Therefore, there is the need for environmental mitigations to preserve the ecosystem.*

Keywords— characterization, ecosystem, basal area, vegetation, above ground biomass (AGB).

I. INTRODUCTION

Mangrove is a coastal ecosystem found in found in tropical and subtropical regions around the world, which are characterized by usually timbered vegetation which is connected to other components of flora and fauna well acclimatized to limiting conditions of salinity, uncombined substrate, little oxygen and a habitat repeatedly submerged by the tides(Maia and Coutinho 2012). Generally Inhabiting in wet soils baggy of brackish to saline estuaries and shorelines in the tropics and sub-tropics (Joshi and Ghose 2003). As well as support for the environmental and marine system, especially and the preservation of fish stocks and biodiversity as it provides food, a shelter for species. As well as establishing an important source of organic material to support marine system. This exported material, reinforced with fungi and bacteria, produces the basis of the food web in the ecosystem (Maia and Coutinho 2012). Globally, they are known to be generality the most productive and unparalleled coastal ecosystems that support an extensive range of goods and services and other marine systems (Aheto *et al*. 2011). The above ground biomass (AGB) is the amount of standing organic material per unit area at a given time, which is correlated to a position of productivity system, an age of trees standing and organ allocation. The estimation of above ground biomass provides increasingly valuable means for making rapprochement among ecosystems and appraisement worldwide productivity styles, provide knowledge is very important as a result of the evaluation study of the technical aspects of forests such as primary productivity of mangroves, nutrient cycling and energy flow. Consequently, biomass data are important in order to comprehend forest ecosystem characteristics to establish the appropriate management system based upon the sustainable yield principle according to (Kusmana *et al*. 1992).

Mangrove trees are highly productive ecosystems with a healthy diversity of flora and fauna in the intertidal regions of tropical and subtropical coastlines. They are theorized to have great ecological importance in shoreline stabilization, alleviation of coastal erosion, sediment, and nutrient retention, storm preservation, flow control, and water quality, besides their normal economic benefit through diverse forest products. However, the situation with regard to the mangrove forests has been retracted because of increased infringement for land to be assigned to food and industrial production and settlements to meet human needs and mangroves are important for their societal value, economic, and ecological (Jachowski *et al*. 2013). Despite scientific consciousness of the large carbon storage potential in mangrove biomass and soils, large areas of mangrove in Southeast Asia have been lost in recent decades to civilization, aquaculture, timber harvesting and anthropogenic activity (Giri *et al*. 2008). Mangroves along the Andaman coast, for example, have declined an estimated 79% between 1961 and 1989, largely due to Human activities including aquaculture (Saenger 2002).

particularly following the 2004 Indian Ocean Tsunami (Barbier 2006). A recent study in the Indo-Pacific region showed that mangroves play a critical role in carbon imprisonment, potentially storing four times as much carbon as other tropical forests, including rainforests (Donato *et al*. 2011). It has been estimated that the loss of the mangroves may reach 60% by 2030 (Satyanarayana *et al.* 2011). Enggano island has an area of about 40 060 hectares. Around 14377.35 hectares (35.89%) is forest area, while the remaining 25 682 hectares (64.11%) is land for other uses such as residential, agricultural land, and etc. The area of mangrove forest ecosystems in Enggano is ± 1414.78 ha (Nashsyah *et al* 2011). The research aims at (1) Identify for mangroves species located (2) analyzing characteristics of mangrove forest , relative density, relative frequency, relative dominance, and importance value index, (3) this research was undertaken as an attempt to estimate the above ground biomass of the trees which have commercial size (diameter 10 cm and over)and relationship with basal(BA) and AGB for mangrove forest communities in island Enggano in relation to the mangrove tree species composition.

II. RESEARCH METHODS

Location and Research Time

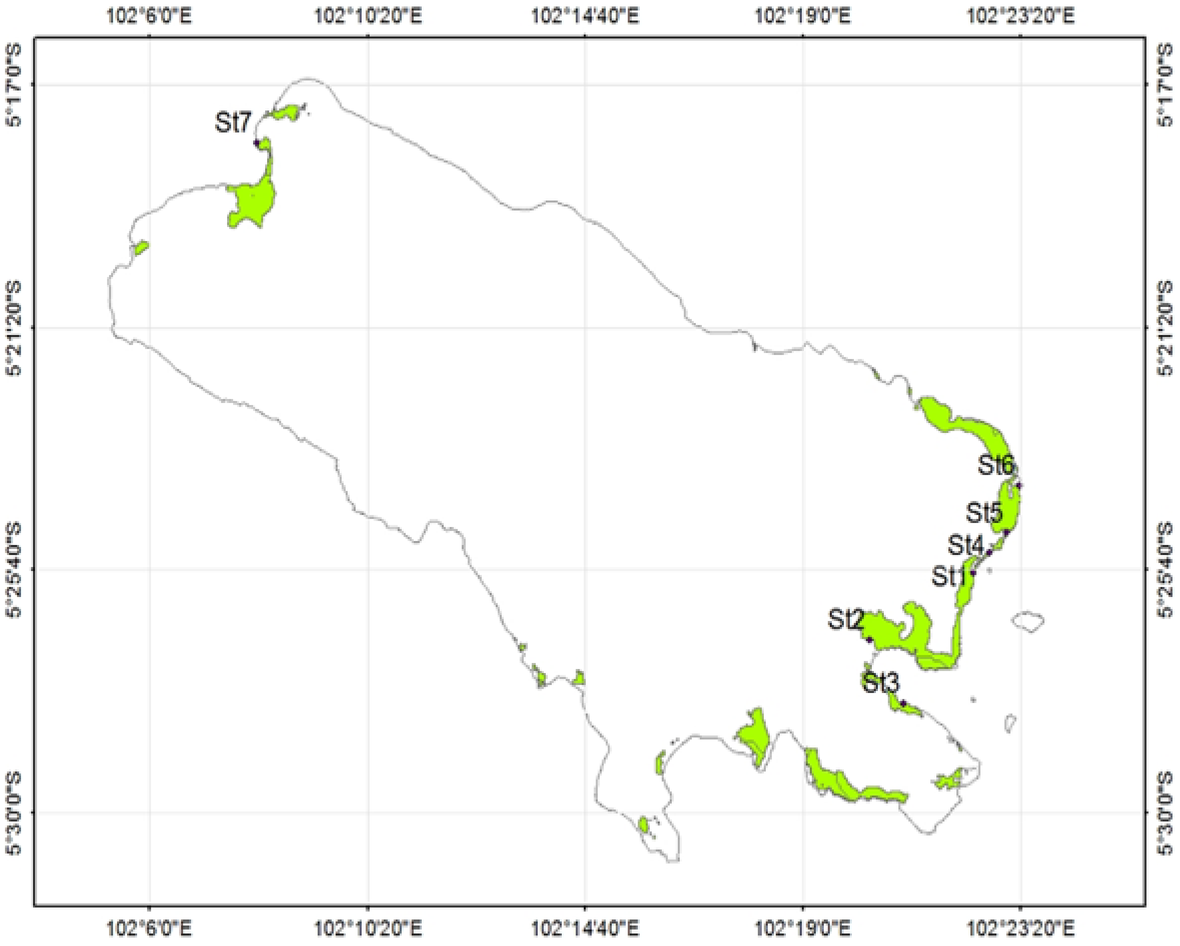

Fig.1: Map of seven research stations in Enggano Island

The study was conducted in Location of research in island Enggano, it was taken seven different stations in multiple regions east and North West of Island, which was located at the coordinates S 05^0: 25' 43.0" to S 05^0: 24 ' 10.0" and E 102^0 22' 22.7" - E 102^0 23' 19.5" Figure1.Enggano located in the zone of the Indian Ocean and administratively included in North Bengkulu, Bengkulu Province. Based on the Decree of the President of the Republic of Indonesia Number 78 Year 2005 on the Management of Small Islands Outermost, that of 92 islands, one of them is Enggano(Nashsyah *et al* 2011).The study was conducted during the three months from November 2015- January 2016.

Materials and Devices Research

The tools used for field data validation include: cameras, locations documented using a GPS, Boats, roll meters, stationery, Raffia rope, and ArcGIS 10.3 are used as a means of processing, interpretation of data and Guidebook classification mangrove.

Method of Data Collection and Analysis

The methods used in this study range from ecological fieldwork to implement, the quadrant transect method is applied(English *et al.* 1994). The data are collected at 10 m2 quadrat random sampling points. Made seven stations laid perpendicular to the shoreline. In order to cover all conditions of the research sites, on each transect, 7 random sampling points were taken using a 10 m×10 m quadrat for the plot. Were laid the seven stations to making sample plots were set up at representative areas in mangrove forest, Line transects were used from seaward to landward (perpendicular to the coastline along the mangrove forest zoning) in the intertidal area. In addition to made the plot size of 10 x 10 for an adult tree, 1 x 1 m (English *et al.* 1994), the seedling and 5 x 5 m for the sapling (Bengen 2002) to assess the condition of mangrove. The determination vegetation of mangrove for each species counted the number of individuals and density of each type and size of each circle mangrove trunk at breast height about 1.3 m for the trees mangrove adult diameter > 4cm. The method used is the method of repetitions single plot random, where the technique of making sub-plot follows the growth stage (English *et al.* 1994).Variables observed, calculated, and analyzed in the study are: (1) species and composition of vegetation, (2) characteristics of mangrove ecosystems, consisting of Population density, relative density, Importance Value Index, Frequency, Relative Frequency, Dominance, Relative Dominance, and Stand Basal Area, (3) above ground biomass of mangrove trees (English *et al.* 1994). The aboveground biomass was determined summing of the biomass of stem. The total aboveground biomass for mangrove species was calculated from the summation of tree biomass found from sampling plot. All data for biomass and stem volume were converted into hectares and used Allometric equations are the most common and widely used method for measuring biomass. The equations are derived from selective sampling of mangrove trees that are representative of the size-classes in the forest, and it is used to estimate the partial weight of trees relative to tree metrics, such as diameter breast height (DBH) and tree height, calculated, and analyzed in the study are: (1) species and composition of vegetation, (2) characteristics of mangrove ecosystems, consisting of Population density, relative density, Importance Value Index, Frequency, Relative Frequency, Dominance, Relative Dominance, and Stand Basal Area, (3) above ground biomass of mangrove trees.

$$\text{Relative density} = \frac{\text{no.of individuals of a species}}{\text{total no.of individuals of all species}} \text{x}100.$$

$$\text{Frequency} = \frac{\text{Number Of Plots In Which a Species Occurs}}{\text{Total Number of Plots Samples}}.$$

$$\text{Relative Frequency} = \frac{\text{Frequency of Species}}{\text{Total Frequency of All Species In Different Plots}} \text{X } 100.$$

$$\text{Dominance} = \frac{\text{Total of Basal Area } of \text{ Each Tree of A Species From All Plots}}{\text{Total Area of All The Measured Plots}}.$$

$$\text{Relative Dominance} = \frac{\text{Total Basal Area of A Species}}{\text{Basal Area of All Species}} \text{X } 100.$$

(IVI) = relative density + relative frequency + relative dominance (English *et al.*, 1994).

(DBH) and tree height, $Y = b * (DBH^2 * H)^a$, Were Y = biomass value is a dependent variable, DBH = Trunk Diameter (diameter at breast height), Taking into account the density as a variable to calculate the biomasswherevalues a and b are regression constant = (*Rhizhophora* = 0,101; *Bruguiera* = 0,150; and others = 0,145), H = Height of tree, a = coefficient (*Rhizhophora* = 0,931; *Bruguiera* = 0,784 and others = 0,827). (Suzuki and Tagawa 1983).

- The Result calculate Relative Closure equals the result Relative Dominance Which is based on BA = µ $DBH^2/4$, DBH= (2πr)/π. Where: BA = Basal Area, DBH=(2πr)/π. (2πr)/π) is the circumference of trees (English *et al.* 1994).

IVI = RDi + RFi + RCi

Information:

IVI: Importance Value Index RD: Relative Density RF: Relative Frequency RC: Relative Closure.

III. RESULTS AND DISCUSSIONS

Characteristics of Mangrove Vegetation

Relative Densityand Relative Frequency

An observation the characteristics of mangrove vegetation in this study concerns on the seven observation locations as the focus for the Relative Frequency, importance value index, estimate the above ground biomass and their relationship with a basal area of the mangrove trees and identification of the species within the study areas. Frequency is the number of sampling

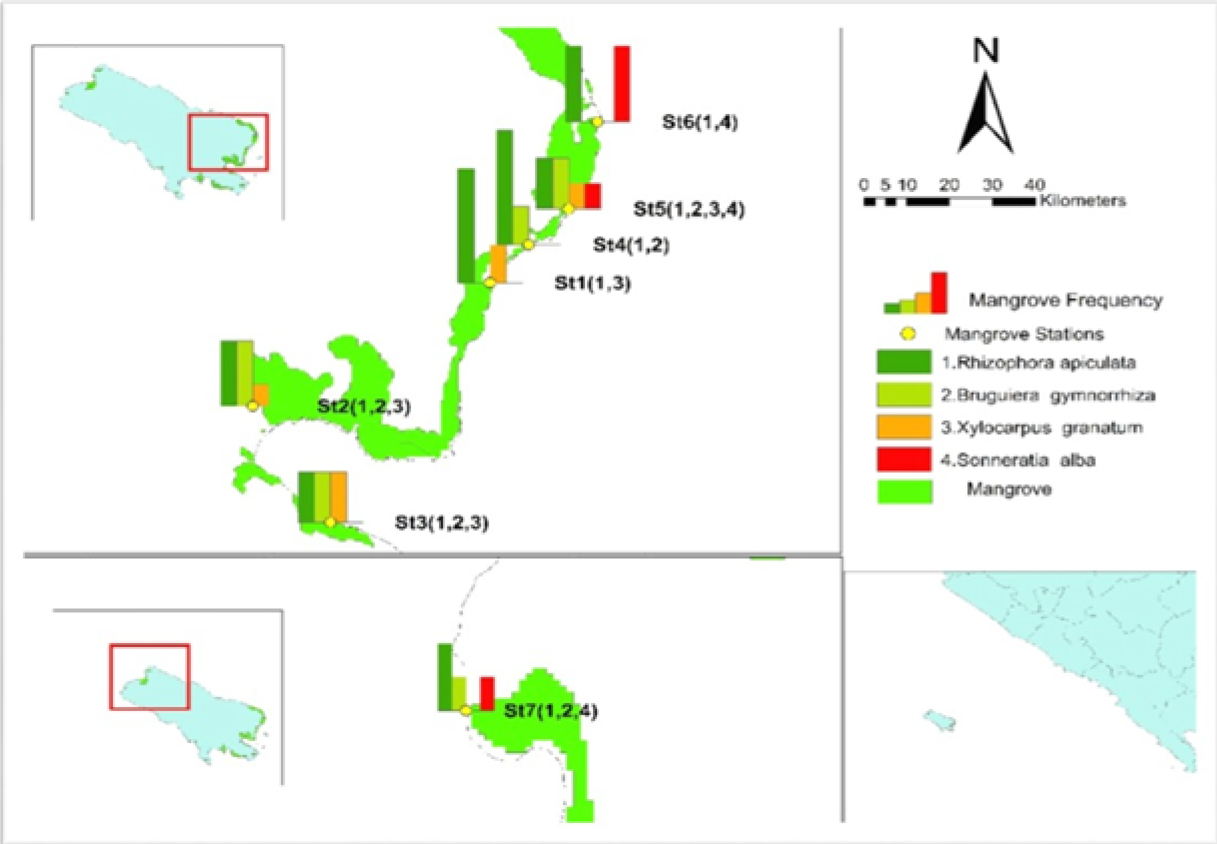

Fig.2:Distribution of Mangrove for all station in Enggano Island in the seven.

units in percent in which a particular species occurs as the probability of finding the species any one plot and only be compared between plots of equal size(English *et al.* 1994)**.** where the relative frequency analysis is given to seven observed locations there are found four identified Figure 3. Proportions of Individuals Density distribution of Mangrovespecies as follows: *R. apiculata*, *B. gymnorrhiza*, *X. granatum*, *S. alba*. The highest value relativefrequencyfor types

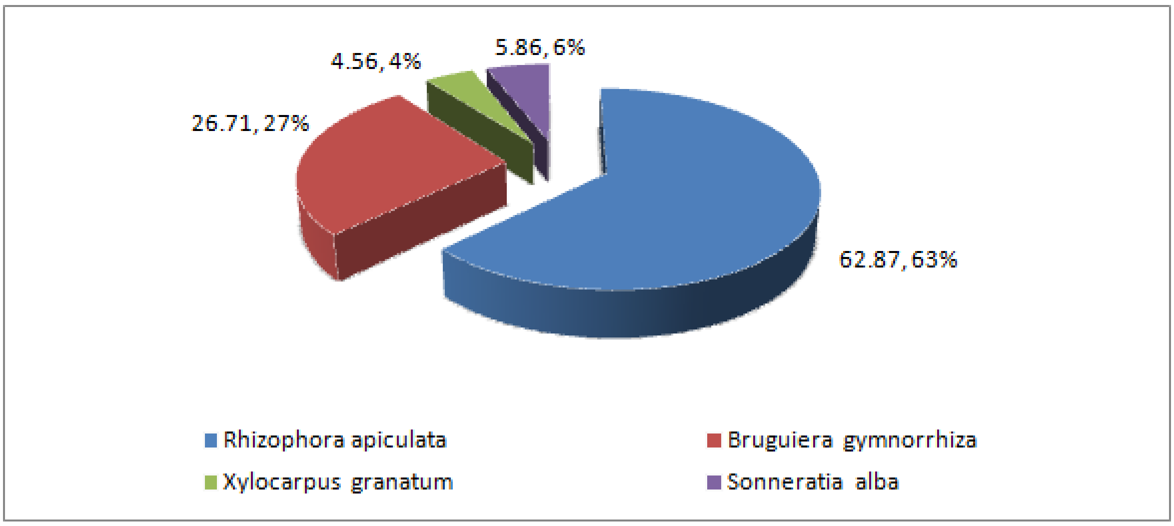

Fig.3:Proportions of Individuals Density distribution of Mangrove in Enggano Island (ind/ha)

in each stationpresented Respectively 75%, 43%, 50%, 33.3% (see Figure.2). To find out the IVI was calculated and analyzed both relative density, relative dominance, relative frequency.Four mangrove species were identified in the seventh stations for Enggano Island was *R. apiculata*, *B. gymnorrhiza*, *S. alba*, and *X. granatum* and represented the relative density of these species (see Figure3).Based on the identification and analysis, mangrove ecosystem where was percentage of each species is given as (1) *R. apiculata*63%, (2) *B. gymnorrhiza* 27% (3) S. alba 6%, and (4) *X. granatum* 4%. Relative density analysis shows figure 3.Show that *R. apiculata* is the most dominant species. Presumably, it has not only vastly zonation but also fast growth rate compared to other vegetation types.See the density of the mangrove landscape photograph Figure 4.

Fig.4: Individuals Density mangroves in Enggano Island.

Relative Closure

Analysis of Relative Dominance of mangrove vegetation in the observed seven station found that: (1) *Rhizophora apiculata* value of 98% in station one, (2) *Bruguiera gymnorrhiza* has the value of 91%, (3) *Sonneratia alba* has a value of 35%, and (4) *Xylocarpus granatum* has value 22% Figure 5. This Relative Dominance analysis of mangrove vegetation in the seven observed locations shows that Figure4.*Rhizophora apiculata* has the highest Relative Dominance value compared to the other species. Presumably, *Rhizophora apiculata* has the ability to adapt and cope with environmental conditions larger compared to other species.

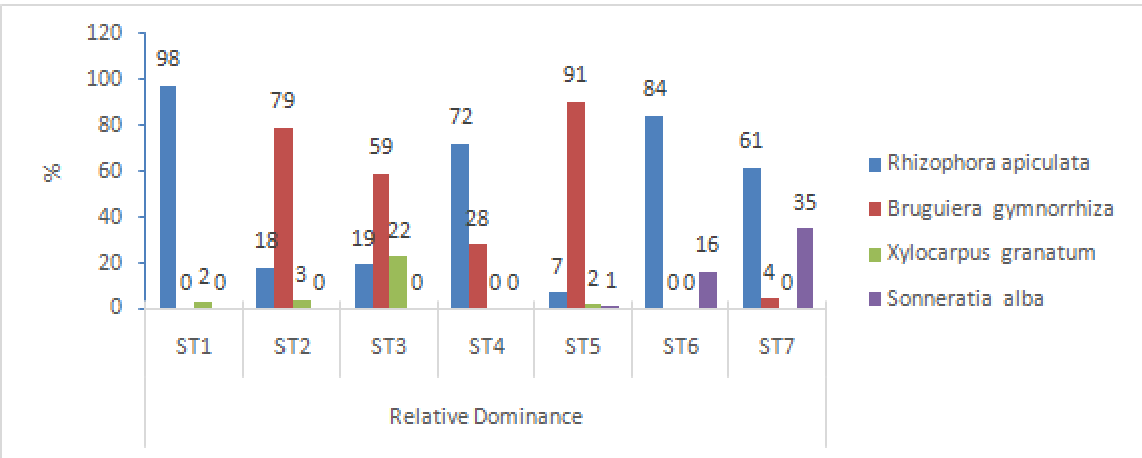

Fig.5:Mangrove species for all station in Enggano Island

Importance Value Index

Importance value index of mangrove vegetation ranges from 0 to 300 (Sambu *et al.* 2014). This IVI will become an overview about the influence or role of a plant in the community within vegetation ecosystem. Analysis of IVI of mangrove vegetation details refers Table 1,(1) R. apiculate reaches 267.57 highest IVI values in the first Station and Lowest was in stationfive (2) *B. gymnorrhiza* 181 highest IVI value in station five and showed the less valuable in station.

Table.1: Important value index of mangrove species for all station in Enggano Island

NO	Species	Importance Value Index						
		St1	St2	St3	St4	St5	St6	St7
1	*Rhizophora apiculata*	267,57	127	101	212	74	220	178

2	*Bruguiera gymnorrhiza*	0	151	126	88	181	0	33
3	*Xylocarpus granatum*	32,431	22	73	0	23	0	0
4	*Sonneratia alba*	0	0	0	0	22	80	89

seven are value 74 in terms of dominance. (3) *X. granatum* the highest IVI value is 73 in station three, Lowest IVI value 22. (4) *S. alba* 89 station seven and lowest are 22 in station five. The Zero values in some stations is non-existence for a type. The findings show that species *R. apiculata*has the most dominant influence in the four types mangrove ecosystem.

Based on the observed and analysis of importance value index of mangrove vegetation, the composition of vegetation in the observed seven locations has heterogeneous, as it is shown by the observation and analysis of the four species mentioned. but it has low-level heterogeneity. In fact, one of the indicators that mangrove ecosystem is healthy is when it has high heterogeneity or when the ecosystem has high biodiversity.

Relation between basal area (BA) and aboveground Biomass (AGB).

Analysis showed above ground biomass in the study areas for higher values basal area, above ground biomass for each of the respectively, *R. apiculata* 47,7 m^2/ha, 60,21 t/ha, *B. Gymnorrhiza* 63,6 m^2/ha, 138, *X. granatum* 13,2 m^2/ha, 20,82 t/ha, *S. alba* 26,9 m^2/ha, 38,02 t/ha, 38 t/ha. The estimated values by means of these allometric equations are shown in Figure 5. Where the basal area depended on the trunk and biomass relied on DBH, Height and (DBH*H) as the independent variables (Suzuki and Tagawa 1983). it has been shown to the value to increase the basal area gave increased aboveground biomass values. From the data analysis showed linearly increased with an increase of basal area, aboveground biomass was strongly related to the basal area in mangrove forests as results of correlation r = 0,9454Figure 6. When BA increase 1 m^2/ha, the biomass increased by 1.7025 ton/ha. The average values for the basal area, estimation based on biomass in study sites, *B. gymnorrhiza* present the highest, at 22 m^2/ha, 41,30 t/ha with *X. granatum* 2,5 m^2/ha, 3.95 t/ha lowest. From the findings, it was depicted that there is a significant indirect effect of a change of characteristic of mangrove forest due to human encroachment evidence by the reduction in *X. granatum* and *S. alba* species population, Therefore, there is the need for environmental mitigations to preserve the ecosystem. the results of this research was comparable to the findings on the study in Sarawak, Malaysia of amount mangrove above ground biomass of *R. apiculata* were 116.79 t/ha. (Arianto *et al.* 2011), again according (Komiyama *etal*.1988) to the findings the biomass ranged from 436.4 t/ha in tall *R. apiculata* forests in Indonesia.

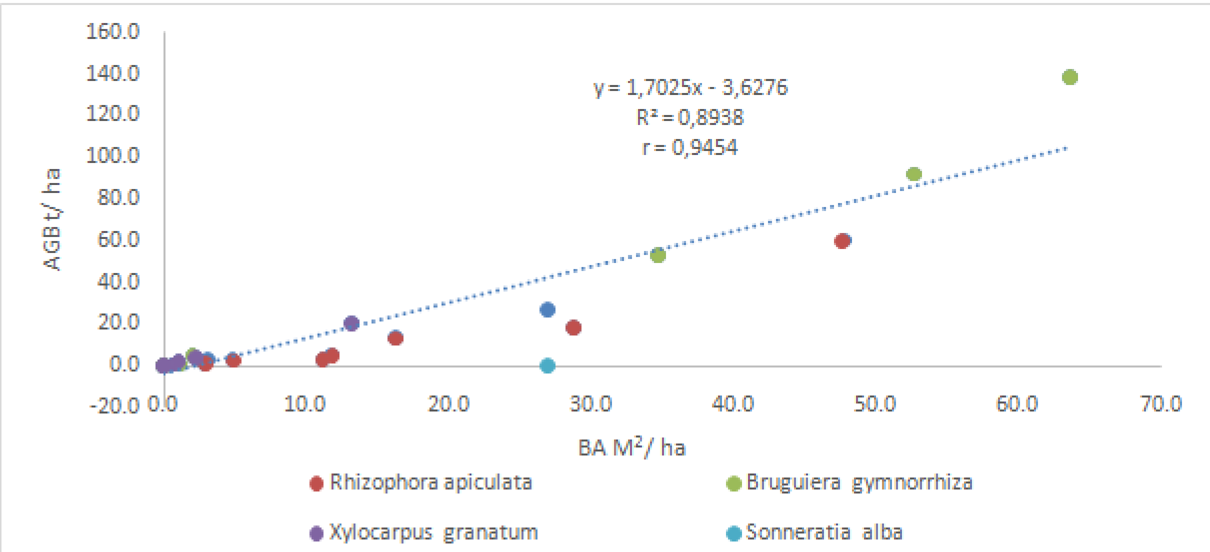

Fig.7:Relation between (BA) and (AGB) of the mangrove species forall station in Enggano Island.

and *R. apiculata*460 t/ha in Malaysia according to (putz and Chan 1986). the ABG for *B. gymnorrhiza* was 94.4 t/ha in south Africa (steinke *et al.* 1995). however, the finding of this research was significantly lower compared to previous studies this was evidenced AGB for *R. apiculata*, *B. gymnorrhizan* species in Enggano Island this might have been attributed by human activity, environmental and climate changes.

IV. CONCLUSION

Based on the field study and data analysis result, it concludes of the four species mangrove vegetation indicates that vegetation is level heterogeneity and it is dominated by species *R.apiculata* in both of the relative density, relative frequency, and Important Value Index and were the highest values for *R. apiculata* and *B. gymnorrhizan*. Analysis showed above ground biomass and basal area, it has been shown to the value to increase the basal area gave increased aboveground biomass values. From the data analysis showed linearly increased with an increase of basal area, aboveground biomass was strongly related to the basal area in mangrove forests as results of correlation r = 0,9454. When BA increase 1 m^2/ha, the biomass increased by 1.7025 ton/ha. From the findings, it is depicted that there is a significant indirect effect of a change of characteristic of mangrove forest due to human encroachment evidence by the reduction in *X. granatum* and *S. alba* species population. According to the classification of the density as described above, Therefore, there is the need to mitigation environmental pressures for preserve the ecosystem.

V. ACKNOWLEDGEMENTS

The authors would like to express their gratitude to IPB – Bogor Agricultural University for its kind support towards this research. and the department of Living Aquatic Resource Management in IPB for giving excellent knowledge, insightful comments and suggestions for making this paper and guide on how to implement the preparation and research related to this paper. Lastly to the team who has participated in data collection in the field.

REFERENCES

[1] Aheto, D. W., Aduomih, A. A. O., Obodai, E. A. Structural parameters and above-ground biomass of mangrove tree species around the Kakum river estuary of Ghana. Annals of Biological Research, 2011, 2 (3): 504, 514.2011.

[2] Arianto, C. I., Hena, A., Kamal, M., and Gandaseca, S. Aboveground biomass production of Rhizophora apiculata Blume in Sarawak mangrove forest. American Journal of Agricultural and Biological Sciences, 6(4), 469-474.2011.

[3] Barbier, E. B. Natural barriers to natural disasters: replanting mangroves after the tsunami. Frontiers in Ecology and the Environment, 4(3), 124-131.2006.

[4] Bengen DG. Pedoman Teknis Pengenalan dan Pengelolaan Ekosistem Mangrove. Pusat Kajian Sumberdaya Pesisir dan Lautan. Institut Pertanian Bogor. Bogor.2000.

[5] Donato, D. C., Kauffman, J. B., Mackenzie, R. A., Ainsworth, A., & Pfleeger, A. Z. Whole-island carbon stocks in the tropical Pacific: Implications for mangrove conservation and upland restoration. Journal of Environmental Management, 97, 89-96. 2012.

[6] English SS., Wilkinson, CC., Baker VV. Survey manual for tropical marine resources. Australian Institute of Marine Science (AIMS).1994.

[7] Giri, C., Zhu, Z., Tieszen, L. L., Singh, A., Gillette, S., & Kelmelis, J. A. Mangrove forest distributions and dynamics (1975–2005) of the tsunami-affected region of Asia. Journal of Biogeography, 35(3), 519-528.2008.

[8] Jachowski, N. R., Quak, M. S., Friess, D. A., Duangnamon, D., Webb, E. L., & Ziegler, A. D. Mangrove biomass estimation in Southwest Thailand using machine learning. Applied Geography, 45, 311-321.2013.

[9] Joshi, H., and Ghose, M. Forest structure and species distribution along soil salinity and pH gradient in mangrove swamps of the Sundarbans. Tropical Ecology, 44(2): 197-206, 2003.

[10] Komiyama, A., Moriya, H., Prawiroatmodjo, S., Toma, T., Ogino, K. Primary productivity of mangrove forest. Biological system of mangroves. Ehime University, Ehime, Japan, 96-97.1988.

[11] Kusmana, c., Sabiham, S., Abe k., and watanabe, H., An Estimation of Above Ground Tree Biomass of a Mangrove Forest in East Sumatra, Indonesia. Tropics, 1(4), 243-257.1992.

[12] Maia, R. C., and Coutinho, R. Structural characteristics of mangrove forests in Brazilian estuaries: A comparative study. Revista de biología marina y oceanografía, 47(1), 87-98.2012.

[13] Nashsyah, H. M., Muhamad, A. H., Gunggung, S., Satria P, U., Fajrin, H., Solehan., Hendra S, S., Hanif., Yusril., Adnan, H., Pirman., Sudaryanto. survey detail rencana pembangunan bandar antariksa di pulau Enggano.2011.

[14] Putz, F. E., and Chan, H. T., Tree growth, dynamics, and productivity in a mature mangrove forest in Malaysia. Forest ecology and management,17(2), 211-230.1986.

[15] Saenger, P. Mangrove ecology, silviculture and conservation. Springer Science & Business Media.2002.

[16] Sambu, A. H., Rahmi, R., and Khaeriyah, A. Analysis of Characteristics of and Use Value of Mangrove Ecosystem (Case Study in Samataring and Tongketongke Sub-Districts, Sinjai Regency).

Journal of Environment and Ecology, 5(2), 222-233.2014.

[17] Steinke, T. D., Ward, C. J., and Rajh, A. Forest structure and biomass of mangroves in the Mgeni estuary, South Africa. Hydrobiologia, 295(1-3), 159-166.1995.

[18] Suzuki, E., and Tagawa, H. Biomass of a mangrove forest and a sedge marsh on Ishigaki Island, south Japan. Nihon Seitai Gakkaishi, 33(2), 231-234.1983.