Journal of Biodiversity and Environmental Sciences (JBES)
ISSN: 2220-6663 (Print) 2222-3045 (Online)
Vol. 8, No. 2, p. 265-274, 2016
http://www.innspub.net

INNSPUB
RESEARCH PAPER
OPEN ACCESS

Species diversity and above-ground carbon stock assessments in selected mangrove forests of Malapatan and Glan, Sarangani Province, Philippines

Ricky C. Barcelete Jr*, Eva Mae F. Palmero[1], Bhegie May G. Buay[1], Cyril B. Apares[1], Lanny R. Dominoto[1], Harold Lipae[1], Ma. Luisa N. Cabrera[1], Mark Anthony J. Torres[2], Elani A. Requieron[1]

[1]*Science Department, Mindanao State University, General Santos, Philippines*

[2]*Department of Biological Sciences, Mindanao State University, Iligan, Philippines*

Article published on February 28, 2016

Key words: *Sonneratia alba, Rhizophora apiculata,* C-stocks.

Abstract

Mangrove ecosystems are known for being the rainforest of the sea. Philippines is bestowed with this naturally rich mangrove ecosystem with diverse floral and faunal species. Despite this natural abundance, mangrove ecosystems are subjected to natural and human induced degradations specifically conversion to fish shrimp ponds that resulted in diminution aside from its effect on terrestrial and oceanic carbon cycling and could also affect its important role in terms of terrestrial and oceanic carbon cycling. This study is conducted to determine the mangrove diversity, distribution and the above-ground biomass and C-stocks in Glan and Malapatan, Sarangani Province. Purposive sampling is implemented in establishing the plots on both sites. Results show eight (8) mangrove species belonging to four (4) families are observed in both areas. Data also reveal that the mangrove ecosystem in Glan Padidu, Glan is undisturbed. *Rhizophora apiculata* and *Sonneratia alba* are found to be dominant on the two sites. Because of the large tree girths and high density of species observed on the studied areas, both forests have the potential to sequester and store large amount of atmospheric carbon. Thus, this study quantifies mangrove tree biomass in view of carbon trading as significant in lessening the effects of global warming.

***Corresponding Author:** Ricky C. Barcelete Jr. ✉ ricky_barcelete@yahoo.com

Introduction

Mangrove forest is also known as the "rainforest of the sea". It grows well on mudflats and banks of tropical and subtropical rivers and coastlines, existing at the boundary of land and water and receiving nutrients from both environments (Ramos, 2013). Mangroves are salt tolerant trees (halophytes) because they contain a complex salt filtration system and complex root system to cope with salt water immersion and wave action. They are also anoxic, adapted to the low oxygen conditions of waterlogged mud. They have these highly developed morphological, biological, ecological and physiological adaptations to extreme conditions that no other group of plants would possess (Kathiresan *et al.,* 2001).

Mangroves are distributed circumtropically. They are confined in saline coastal sediment habitats in the tropics and subtropics mainly between latitudes 30° N and 30° S (Ramos, 2013). Within this range, temperature, moisture and large currents strongly affect their distribution (Kathiresan *et al.,* 2001). Rainfall also influences mangrove distribution, largely by its effect on salinity (Ramos, 2013). Human intervention, too, plays a role on mangrove distribution.

Mangroves have massive ecological value (Kathiresan *et al.,* 2001). They unveil protection for coastal erosion, securing coastal communities from storm surges, waves, tides and currents. Above and beyond, it exhibits facility of protected nursery area for marine life and support for fisheries production and aquaculture and functions as recreational grounds for wildlife enthusiasts. Moreover, mangrove forests provide important ecosystem services, and play important roles in terrestrial and oceanic carbon cycling (Liu *et al.,* 2013).

Because climate change is progressively and globally concerned, the potential of the mangrove forestry to stock carbon is recently highlighted. This ecosystem is made up of carbon-based life forms in plant biomass and soil through litter fall. It significantly helps in concentrating carbon dioxide in the atmosphere. Although carbon sequestration has been assessed frequently in terrestrial ecosystems, the carbon stocks in mangrove forests have often been disregarded especially here in the Philippines (Abino *et al.*, 2014). Philippines is bestowed with naturally rich mangrove ecosystem with diverse floral and faunal species. The Philippines alone hold 37 mangrove species out of estimated 73 species recognized throughout the world (Ramos, 2013). The province of Sarangani is one of the places in the Philippines observed with coastal resources including mangrove community. Using combined data of municipal profiles and Provincial Environment and Natural Resources Office (PENRO), the mangrove forestlands were estimated at 267.6 ha (De Jesus *et al.*, 2001).

Despite this natural abundance, mangroves are subjected to natural and human-induced degradations specifically conversion to fish and shrimp ponds that resulted to diminution (Abino *et al.,* 2014). Therefore, this study aims to assess species diversity as well as to estimate above-ground biomass, and C-stocks in one of the coastal zones in Philippine archipelago.

Materials and methods

Study area

This study was carried out in Sarangani Province located in southeastern Mindanao, geographically lies between 05°56'24.255"- 05° 50'24.204"N and 125°16'51.154"-125°12'24.297"E (Fig. 1). The researchers identified two areas as the study sites in the municipalities of Malapatan and Glan. The precise locations of each plot (Fig. 2) were determined through the Global Positioning System (GPS).

Data collection

A total of 32 plots were established to determine the species composition and the structure of the area. Sixteen (16) plots were done in Glan Padidu, Glan Sarangani Province and another 16 plots in Malapatan, Sarangani Province. The plots were randomly selected covering the different zones including the landward, middle ward and seaward mangroves. The plot dimension of 10 m × 10 m constitutes the main plot, wherein mangroves within the plot were measured and named. Purposive sampling was implemented in establishing the plots where mangroves are sufficient. Inside each plot, girth size was measured from its breast height. In terms of multiple branches aligning the breast height, with the exception of family *Rhizophoraceae,* the measure of the girth size of one branch will be added to another branch to come up with a measurement. Species located inside the sampling quadrates were only considered for species inventory (Jumawan *et al.,* 2015).

Fig. 1. (A) Map of the Philippines, showing Malapatan and Glan, Sarangani Province in Mindanao area, (B and C) Map showing the locations of the sampling sites in Malapatan and Glan, Sarangani Province respectively.

Species inventory

Mangrove species inside the plots were determined and measured for further data analyses. Species and some associated mangroves located outside the plot but can be found in the area were also recorded. Reliable identification guides were used to identify mangrove species (Primavera *et al.*, 2008; Calumpong, 2007).

Identifying saplings and seedlings

Saplings are identified as young trees with girths of less than 10 cm and a height of at least 1.3 cm. Seedlings are young plants with a height of less than 1.3 m and are not branching. Saplings and seedlings present inside the plot were counted, measured, and identified.

Biodiversity measurements

Biodiversity index is the list of all the species found within the area of interest and consists of Dominance, Shannon, Evenness, Species Richness and Number of individuals. Paleontological Statistics (PAST) Software was used in measuring biodiversity indices. Species diversity is described according to the Shannon Index (H) as per the following equation:

$$H = -\sum_{i=1}^{s}(p_i \, \mathrm{x} \ln p_i) = -\sum_{i=1}^{s}(\frac{n_i}{N} x \ln \frac{n_i}{N})$$

In the formula given above, S is the total number of species, N is the total number of individuals, and n_i is the number of individuals of the i-th species. n_i/N is equivalent to p_i, the probability of finding the i-th species (Magurran, 2004).

Data analysis

Mangrove forests are complex ecosystems that can be found along intertidal zones and play a very significant role in marine ecological balance. Vegetation analysis provides a comprehensive species list, definition of plant communities and the identification of successional processes (Steinfield *et al.*, 2007).

Fig. 2. Sampling plots in Malapatan and Glan, Sarangani Province, Mindanao Island, Philippines.

These are the formulas used for the analysis:
Population Density = Number of Individuals/Total area sampled.

Frequency = Number of plots in which a species occurs/Total number of plots sampled.

Dominance = Total of basal area of each tree of a species from all plots/Total area of all measured plots
Relative Density = (Number of individuals of a species/Total number of individuals of all species) × 100.

Relative Dominance = (Total basal area of a species/Basal area of all species) × 100.

Relative Frequency = (Frequency of species/Total frequency of all species in different plots) × 100.

Importance Value = Relative Density + Relative Frequency + Relative Dominance solve.

The importance value index (IVI) which indicates the structural importance of each species in the community was obtained by adding the percentage values of relative frequency (RF), relative dominance (RDom) and relative density (Abino *et al.,* 2014).

Carbon stored in mangroves ecosystem is measured through the carbon present in the biomass.

Assessment of above ground biomass were calculated using the allometric equation for mangroves, where only parameters of diameter and wood density were used. The maximum diameter of trees included in the derivation of this equation was 49 cm with a total number of 104 trees (Abino *et al.*, 2014). Its coefficient of determination (R^2) is 0.98 which is, comparably reliable with allometric equations derived for natural stands (Chave *et al.,* 2005; Hossain *et al.*, 2008; Kauffman and Cole, 2010). It was developed by Komiyama *et al.* (2005) for Southeast Asian mangroves. The following general equation was used:

$$B = 0.251\, \rho\, (D)^{2.46}$$

were B stands for above-ground biomass (kg), ρ is the wood density of the species (g/cm^3), and D is the diameter at breast height or dbh (cm) . The total above-ground biomass of individual mangrove species per plot in both sites was solved. The values unraveled per plot were summed for all plots in each site and averaged to get the mean biomass which was then converted to tons per hectare (Abino *et al.,* 2014). Carbon pools of aboveground biomass were then determined by multiplying the biomass carbon concentration (percentage). Since the carbon concentration of wood is usually a little less than 50%, it is also common practice to convert biomass to carbon by multiplying by 0.46–0.5 (Kauffman and Donato, 2012). In this case, an average of 47% was used to estimate carbon stock as based on published carbon concentrations of dominant mangrove species available on both sites.

Results and discussion

Species inventory

A total of ten (10) mangrove species belonging to five (5) families were observed in both sites during the sampling period. Eight (8) species were observed in all plots established namely: *Avicennia marina, A. rumphiana, Bruguiera gymnorrhiza, B. sexangula, Ceriops tagal, Rhizophora apiculata*, *R. mucronata* and *Sonneratia alba* (Table 1).

Table 1. List of mangrove species observed inside the plots of each sites.

Species	Family	Common name
Avicennia marina	*Avicenniaceae*	Bungalon, apiapi, miapi
Avicennina rumphiana	*Avicenniaceae*	Bungalon, apiapi, miapi
Bruguiera gymnorrhiza	*Rhizophoraceae*	Pototan, busain
Bruguiera sexangula	*Rhizophoraceae*	Pototan
Sonneratia alba	*Lythraceae*	Pagatpat
Ceriops tagal	*Rhizophoraceae*	Tungog, tangal
Rhizophora apiculata	*Rhizphoraceae*	Bakhaw lalaki
Rhizophora mucronata	*Rhizophoraceae*	Bakhaw babae

Nypa fruticans and *Terminalia catappa* were associated mangrove species found outside the plots (Tables 1 and 2). Family *Rhizophoraceae* got the highest number of extant species with 5 mangrove species. The recorded mangroves normally thrive along the coastal municipalities of Sarangani Bay based on the previous studies conducted by Mullet *et al*, (2014) and Natividad *et al*, (2015) on vegetation analyses, soil characteristics and community structures in the area.

Table 2. List of associative mangrove species observed outside the plots of each sites.

Species	Family	Common name
Nypa fruticans	*Arecaceae*	Nipa, sasa
Terminalia Catappa	*Combretaceae*	Talisay

Only six (6) true mangrove species were found in Malapatan together with the other two associated mangroves. This number is quite lower compared to the previous study conducted in 2015 by Mullet *et al* where they listed 7 species. *Xylocarpus granatum* and *B. cylindrica* were not found during the sampling time however, three (3) new records were included namely *A. rumphiana, C. tagal* and *R.* mucronata. The establishment of plots could have affected the number of recorded species which caused the difference in the species.

Moreover, the mangroves found in Malapatan were less copious having a total of 275 individuals observed. *S. alba* dominated the mangrove forest in the area with 122 individuals followed by *R. apiculata* and *R. mucronata* with 122 and 28 individuals, respectively (Table 3). It was also noted that the vegetation in the area was not as dense compared to the other site due to its close proximity to the residential areas. The mangrove cover in the area is only 53 hectares and is primarily composed of secondary and primary growth trees (Mullet *et al.*, 2015). The mangrove forests in this municipality is also frequently flooded and other man-made disturbances are evident which conclude the limited number of mangrove species observed.

Table 3. Species Composition and abundance of Mangrove species in Glan and Malapatan.

Species	Glan	Malapatan	Total
Avicennia marina	22	21	43
Avicennia rumphiana	24	1	24
Bruguiera gymnorrhiza	1	0	1
Bruguiera sexangula	6	0	6
Sonneratia alba	45	122	164
Ceriops tagal	2	1	3
Rhizophora apiculata	299	102	401
Rhizophora mucronata	0	28	28
Total Number of Species found	399	275	674

On the other hand, seven (7) true mangrove species were listed in Glan (Table 3). *B. gymnorrhiza* and *B. sexangula* were present in the area and were not found in the other site. The other species recorded in Malapatan were also found in the site. *R. mucronata* was also found in the area however, the number of individuals were not counted because this species was found outside the established plots.

Table 4. Mangrove seedlings and saplings observed in Glan, Sarangani Province.

Mangrove Species	Seedlings	Saplings	Total
A. marina	7	2	9
A. rumphiana	16	0	16
B. sexangula	0	1	1
R. apiculata	18	112	130
S. alba	23	6	24

There were a total of 399 individuals observed in the area dominated by *R. apiculata* with *a* count of 299 individuals (Table 3). Mangroves found in Glan were of high abundance due to the absence of man-made activities thus having vast number of mangroves observed in each plot. Some plots however contained fewer individuals but it can be explained by the huge diameter at breast height of some of the species. The mangrove forest in the site is primarily composed of primary, secondary and tertiary growth trees from seaward to landward due to its undisturbed nature that means it is not influenced by man-made activities as compared to the other site. Also, rehabilitation is done in the area and the locals are well-informed of the importance of the mangal community within the vicinity.

Regeneration of saplings and seedlings

A total of 6 species regenerated on both sites including *A. marina, A. rumphiana, B. sexangula, R. apiculata, R. mucronata* and *S. alba* (Tables 4 and 5). Regeneration in Glan was relatively higher with a total of 185 individuals of which 64 are seedlings and 121 are saplings. This was dominated by *R. apiculata* which had the highest regeneration count of 130 individuals. Meanwhile, Malapatan seedlings and saplings were lower in number with only 85 individuals from three species namely *R. apiculata, R. mucronata* and *S. alba*. Of the total count, 49 were seedlings while 36 were saplings the seedlings mainly from *R. apiculata* and *S. alba*. The presence of regeneration indicates that the both mangrove forests are thriving despite the relatively low counts.

Table 5. Mangrove Seedlings and saplings observed in Malapatan, Sarangani Province.

Mangrove Species	Seedlings	Saplings	Total
R. apiculata	42	12	54
R. murcronata	5	3	8
S.alba	2	21	23
	49	36	85

Biodiversity measurements

Table 6 shows the results on the biodiversity indices in both of the mangrove forests. The mangroves in Glan were found to be higher in terms of species richness (2.4375), no. of individuals (23.5625) and dominance (0.678113) which concludes that the mangroves found in the said area is undisturbed and is growing naturally. On the other hand, the mangroves found in Malapatan were found to be higher in terms of Shannon (0.780331) and evenness (0.925631) which concludes that the mangroves found in the said area has been influenced by man-made activities that also resulted in the distribution of mangroves were uniform throughout the area. Data findings showed that the results in Malapatan were quite different with the former study by Mullet *et al* (2015). However, the difference must be verified further to have definite assumptions regarding biodiversity measurements on the area.

Table 6. Biodiversity Indices of Mangrove Species found in Glan and Malapatan.

Biodiversity Indices	Glan	Malapatan
Species Richness	2.25	2.4375
No. of individuals	23.5625	16.4375
Evenness	0.0810881	0.925631
Shannon	0.522669	0.780331
Dominance	0.678113	0.492769

Table 7. Vegetation Analysis of Mangroves on Glan Padidu, Glan, Sarangani Province

Species	RPD(%)	RF(%)	RDOM(%)	SIV Ranking
R.apiculata	74.27	41.67	4.38	1
S.alba	11.14	36.11	4.30	2
A.marina	5.84	11.11	0.64	3
A.rumphiana	6.37	2.78	0.35	4
B.sexangula	1.59	2.78	0.03	5
C.tagal	0.53	2.78	0.08	6
B.gymnorrhiza	0.27	2.78	0.23	7

Vegetation analysis

The vegetation analysis of mangroves in Glan as shown in Table 7 revealed that the species *R. apiculata* ranked highest in terms of Relative Population Density (RPD), Relative Frequency (RF) and Relative Dominance (RDOM) with values of 74.27%, 41.67% and 4.38%, respectively. This is then followed by *S. alba* with RPD, RF and RDOM values of 11.14%, 36.11% and 4.30%, respectively. *R. apiculata* was present in high abundance in the site and dominated the entire mangrove forest.

Table 8. Vegetation Analysis of Mangroves on Malapatan, Sarangani Province.

Species	RPD(%)	RF(%)	RDOM(%)	SIV Ranking
S.alba	46.39	40	81.24	1
R.apiculata	35.36	40	13	2
R.mucronata	9.89	10	0.78	3
A.marina	7.89	7.59	4.87	4
C.tagal	0.38	2.50	0.11	5

Consequently, results on the vegetation analysis of mangroves in Malapatan coincides with the former study especially on the species with high values. *S. alba* had an RPD value of 46.39%, RF value of 40% and RDOM value of 81% (Table 8). This species were found in high numbers with sizes (based on the dbh measurements) relatively bigger than the other species. On the other hand, *C. tagal* obtained the lowest values having RPD, RF and RDOM values of 0.38%, 2.50% and 0.11%, respectively as marked by its less abundance in the area (Table 8).

Above-ground biomass and carbon stock analysis

The above-ground biomass of the mangrove trees was determined through establishing relationship between biomass of the trees and the readily measured main stem diameter. Main stem diameter was expressed as the diameter at 1.37 m above the ground (dbh), or in the case of *Rhizophora*, the diameter above the highest stilt root (Kauffman and Donato, 2012).

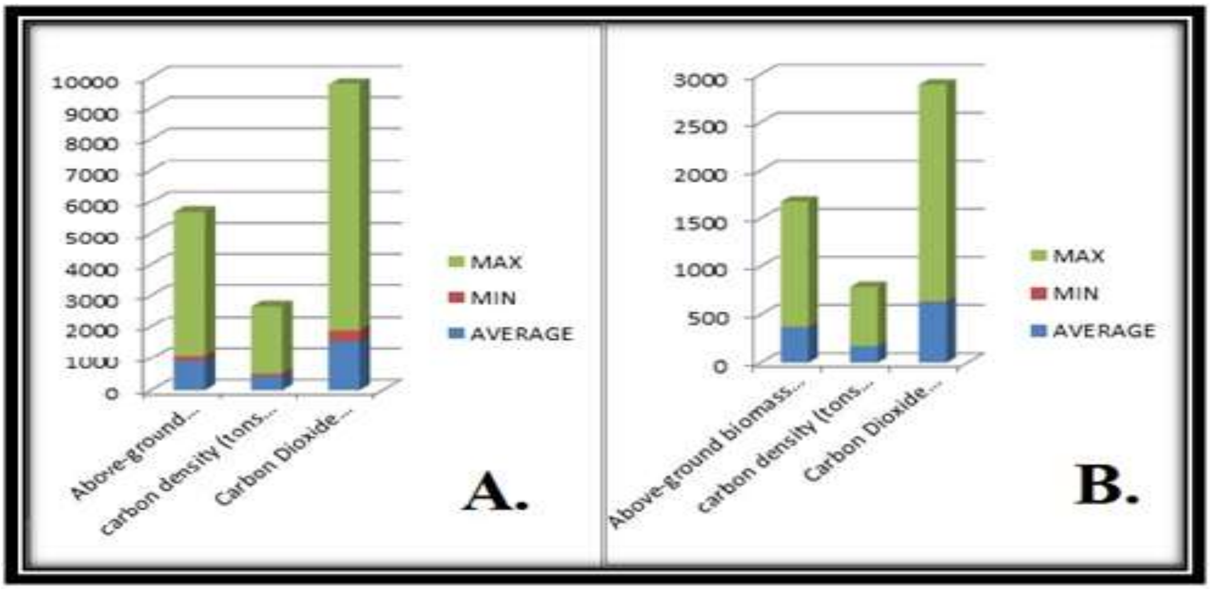

Fig 4. Bar chart showing the results of Carbon Stocks in (A) Glan Padidu, (B) Malapatan, Sarangani Province.

On the stand level, the mangrove forest of Glan has an average above-ground biomass of 901.17 t ha- ranging from 194.07 t ha- to 4567.93 t ha- while Malapatan mangal has a total biomass of 366.70 t ha- covering from 4.08 t ha- to 1306.02 t ha-. The total carbon pool on the first site varied from 91.21 t C ha- to as high as 2146.93 t C ha- with a mean value of 423.55 t C ha-. The second site on the other hand has an average carbon stock of 172.35 t C ha- extending from 1.92 t C ha- to 613.83 t C ha- based on the carbon concentration used. These carbon density values have carbon dioxide equivalents that were sequestered and stored in the above-ground biomass. In detail, the above-ground biomass in Glan with its total carbon pool is equivalent to 1554.43 t CO_2 ha- reaching from 334.75 t.

CO_2 ha^- to as much as 7879.22 t CO_2 ha^- . On the other hand, Malapatan with its carbon stock component sequestered an equivalent of 632.51 t CO_2 ha^- ranging from 7.03 t CO_2 ha^- to 2252.75 t CO_2 ha^-.

The two sites were comparably significant for their high carbon stock potential and the ability of the mangroves flourishing in these mangals show promising results in sequestering carbon. These mangrove forests contribute extensively in mitigating climate change due to the continuous increase of carbon levels in the atmosphere which is a global concern.

Conclusion

Figure 4 shows that a higher diversity index was perceived in the natural mangrove stand in Glan Padidu, Glan compared to Lun Padidu, Malapatan due to natural and human made disturbance. Attributed to the dominance of some species located on the two sites were *R. apiculata* and *S. alba,* respectively. Moreover, Glan Padidu mangrove forest also has a greater carbon pool value. The large tree girths and high density of species observed in these forests show a great potential to sequester and store large amount of atmospheric carbon. It is also note worthy that this study quantifies mangrove tree biomass in view of carbon trading as significant in mitigating the effects of global warming.

Acknowledgement

The researchers would like to thank the people of Brgy. Glan Padidu, Glan Sarangani, especially to the barangay officials for lending us their assistance in guiding us through the mangrove fields and giving us basic information regarding the mangroves. The researchers would also like to give thanks to Rabor Family for lending us their aid in terms of sheltering our needs in Brgy. Lun Padidu, Malapatan Glan Sarangani. Lastly, the researchers would like to extend our gratitude to Prof. Ron Bigsang for giving us help on analyzing carbon pool present in the mangrove stand.

References

Abino C, Castillo Jose Alan A, Lee, Young Jin. 2014. Species Diversity, Biomass, and Carbon Stock Assessments of a Natural Mangrove Forest in Palawan, Philippines. Pakistan Journal of Botany, **46(6),** 1955-1962.

Calumpong, Hilconida P. 2007. Field Guide to the Common Mangroves, Seagrasses and Algae of the Philippines

Chave J, Andalo C, Brown C, Cairns MA, Chambers JQ, Eamus D, Folster D, Fromard F, Higuchi N, Kira T, Lescure JP, Nelson BW, Ogawa H, Puig H, Riera B, Yamakura T. 2005. Tree allometry and improved estimation of carbon stocks and balance in tropical forests. Oecologia **145,** 87-99.

De Jesus Edgar A, Diamante-Fabunan, Dolores Ariadne D, Nañola Cleto L, White, Alan T, Cabangon Hermenegildo J. 2001. Mangrove Community. Coastal Environmental Profile of the Sarangani Bay Area Mindanao, Philippines. Coastal Resource Management Project of the Department of Environment and Natural Resources supported by the United States Agency for International Development, 22-37.

Hossain M, Othman S, Bujang JS, Kusnan JS. 2008. Net primary productivity of Bruguiera parviflora (Wight & Arn.) dominated mangrove forest at Kuala Selangor, Malaysia. For. Ecol. Manage **255,** 179-182.

Liu, Hongxiao, Hai Ren, Dafeng Hui, Wenqing Wang, Baowen Liao, Qingxian Cao. 2014. Carbon stocks and potential carbon storage in the mangrove forests of China. Journal of Environmental Management **133,** 86–93.

Kathiresan K, Bingham BL. 2001. Biology of Mangroves and Mangrove Ecosystems. Advances in Marine Biology **40**, 81-251.

Kauffman JB, Cole TG. 2010. Micronesian mangrove forest structure and tree response to a severe typhoon. Wetlands **30,** 1077-1084.

Kauffman JB, Donato DC. 2012. Protocols for the measurement, monitoring and reporting of structure, biomass and carbon stocks in mangrove forests. Working Paper **86**, 1-33.

Mullet Earl Kevin C, Haydn Lacorte Giuseppe, Hamiladan Rea Mae A. 2014 Assessment of Mangrove Species and its relation to soil substrates in Malapatan, Sarangani Province, Philippines. Journal of Biodiversity and Environmental Sciences **5(4),** 100-107.

Nipithwittaya, Sureeporn and Bualert, Surat. 2012. Above Ground Carbon Sequestration in Mangrove Forest Filtration System. Journal of Applied Sciences **12,** 1537-1546.

Natividad. 2015. Vegetation Analysis and Community Structure of Mangrove in Alabel and Maasim Sarangani. Journal Agricultural and Biological science **10(3),** 97-102

Primavera JH. Ph. D. 2009. Field Guide to Philippine Mangroves.

Ramos Ma, Junemie Hazel L. 2013. Field Guide to Mangrove Identification and Community Structure Analysis.

Rath Anthony B. 2015. Mangrove Importance. World Wild Fund for Nature.