Open Journal of Ecology, 2021, 11, 462-473
https://www.scirp.org/journal/oje
ISSN Online: 2162-1993
ISSN Print: 2162-1985

Carbon Sequestration Potential of Tree Species at Isabela State University Wildlife Sanctuary (ISUWS), Cabagan, Isabela, Philippines

Julius G. Pascua[1], Gerryc P. Alfonso[1], Rocel S. Galicia[2]

[1]College of Agriculture and Forestry, Tarlac Agricultural University, Camiling, Philippines
[2]College of Forestry and Environmental Management, Isabela State University, Cabagan, Philippines
Email: geralf.0987@gmail.com

How to cite this paper: Pascua, J.G., Alfonso, G.P. and Galicia, R.S. (2021) Carbon Sequestration Potential of Tree Species at Isabela State University Wildlife Sanctuary (ISUWS), Cabagan, Isabela, Philippines. *Open Journal of Ecology*, **11**, 462-473.
https://doi.org/10.4236/oje.2021.115030

Received: April 8, 2021
Accepted: April 29, 2021
Published: May 26, 2021

Copyright © 2021 by author(s) and Scientific Research Publishing Inc.
This work is licensed under the Creative Commons Attribution International License (CC BY 4.0).
http://creativecommons.org/licenses/by/4.0/
Open Access

Abstract

This study is conducted to assess the amount of carbon stored in the above-ground biomass of the tree species at the Isabela State University Wildlife Sanctuary (ISUWS). A total of 34 different tree species were found with 285 individuals were identified with a total of 47.50 t/ha Carbon stock and 164.09 t/ha of accumulated CO_2. It was found in the study that *Alstonia scholaris* contains the largest amount of above-ground biomass (AGB) with a mass of 20.97 t/ha and Carbon stock of 9.44 t/ha followed by *Samanea saman* with a mass of 13.40 t/ha and Carbon stock of 6.03 t/ha. Based on the result and conclusion of this investigation, the following recommendations were drawn: Conduct a study concerning the carbon emission of the area to determine the relationship with its carbon sequestration potential; and conduct tree planting activity to open areas in the study site to increase its carbon stock potential and fully serve the purpose of the area as a wildlife sanctuary.

Keywords

Carbon Sequestration Potential, Tree Species, Isabela State University Wildlife Sanctuary

1. Introduction

Global warming is among the most dreaded problems of this millennium which just represents one aspect of climate change. This is caused mostly by increasing concentrations of greenhouse gases in the atmosphere resulting in changes in climate pattern. Greenhouse gases (GHGs) which are primarily carbon dioxide, methane, nitrous oxide and others have influenced the earth's climate system

[1]. Among the GHGs, carbon dioxide (CO_2) is the most important and abundant gas in the atmosphere and is responsible for more than half of radiative forces along with the greenhouse effect [2]. Forest ecosystem plays a very important role in the global carbon cycle by sequestering a substantial amount of CO_2 from the atmosphere [3]. Trees take up CO_2 from the atmosphere and store carbon in their biomass (roots, stems, and foliage) through the process of photosynthesis [4]. In 1990 alone, it is estimated that the world tropical forests were a net source of carbon (1.6 billion t) due to anthropogenic activities including land-use changes and forestry activities, primarily tropical deforestation [5]. The Philippine forests in particular, through massive deforestation, were found to have contributed about 3045 tons of Carbon to the atmosphere since the year 1500 up to the present era [2].

The Kyoto protocol provides flexible mechanisms, where Clean Development Mechanism (CDM) is most relevant for developing countries such as the Philippines [6] which have potential for carbon trading. Due to the importance of forest contributions to global climate change, research on Carbon budgets in forest ecosystem has been intensive in the Philippines. However, there are still significant gaps in the current understanding of the carbon sequestration potential of different plantation species in the country [2]. Hence, this study intends to assess the amount of carbon stored in the above-ground biomass of the tree species at the Isabela State University Wildlife Sanctuary (ISUWS).

2. Review of Related Literature

2.1. Method of Estimating Above-Ground Biomass

The mass of living organisms in a forest is called the biomass. Most of the biomass in a forest is in trees, and the focus of methods for estimating biomass is measuring the above-ground portion of trees [7]. It is the most important and visible carbon pool of the terrestrial forest ecosystem [8].

There are two approaches in measuring the above-ground biomass (AGB). The first one is the destructive method of tree biomass estimation and second is the non-destructive method. The former method is destructive and is not feasible for a large-scale analysis but experts generally agree that the harvest method is the most accurate and direct method in estimating the aboveground biomass and the carbon stocks stored in the forest ecosystems [3]. The latter method estimates the biomass of a tree without felling. This method of biomass estimation is applicable for those ecosystems with rare or protected tree species where harvesting of such species is not very practical or feasible [3].

2.2. Carbon Stock Estimation

Carbon stock is the term used for the carbon stored in terrestrial ecosystems, as living or dead plant biomass [9]. Estimation of the magnitude of sinks and sources of carbon requires reliable estimates of the biomass of forests and of individual trees [10]. As an overall estimate, the carbon content of biomass in the Philippines ranges from 41% to 49% with an average close to 45%. This is a little lower than the IPCC default value of 50% [11]. A study conducted on the carbon content of wood samples collected from secondary forests from several locations in the Philippines and reported that for Philippine biomass, a default value of 45% could be used in determining carbon stock in trees [12]. Some studies in carbon stock assessment in the Philippines use this amount of carbon like in the study in the Reservation Area of Kalinga State University which computed a total of 475.25 t/ha of carbon in [13]. Also the 45% carbon content of the tree biomass were used in the study in Kapatagan, Lanao Del Norte accumulated a total of 257.16 Mg/ha [14].

2.3. Carbon Stock in the Philippines

Tropical forests have a valuable role in relation to climate change, being a source and sink of carbon. The study of Lasco and Pulhin reviews the state of knowledge on carbon stocks and rate of sequestration of various forest ecosystems in the Philippines [6]. Carbon density ranges widely from less than 5 t/ha to more than 200 t/ha in the following order: old growth forests; secondary forest; mossy forest; mangrove forest; pine forest; tree plantation; agroforestry farm; brushlands; grasslands. Carbon sequestration ranges from less than 1 t/ha/yr in natural forests to more than 15 t/ha/yr in some tree plantations. Land-use change and forestry make an important contribution in the national emissions and sinks. It is estimated that Philippine forest lands are a net sink of greenhouse gasses (GHG) absorbing 107 Mt CO_2 equivalent in 1998, about equal to the total Philippine GHG emissions. The clean development mechanism (CDM) presents a clear opportunity for Philippine forestry, if the threats are properly addressed [6].

3. Materials and Methods

3.1. Materials

The materials used in the establishment of sampling quadrats are bolo, pegs and nylon rope. In the collection and preservation of leaf specimens, field note, presser, pruning shear, denatured alcohol, packing tape, specimen tag and sacks were used. After randomly choosing the coordinates of the base corner of sample plots, they were located with the used of Global Positioning System (GPS) and the base stake was placed on the ground.

3.2. Establishment of Quadrats and Transects

The 20 sample plots having the size of 20 m × 20 m were laid out within the study area (**Figure 1**) using completely random sampling [7]. The approach in laying out the sample plots is by choosing random numbers from within the latitude and longitude of the study site. After randomly choosing the coordinates of the base corner of sample plots, they were located with the used of Global Positioning System (GPS) and the base stake was placed on the ground. It was located

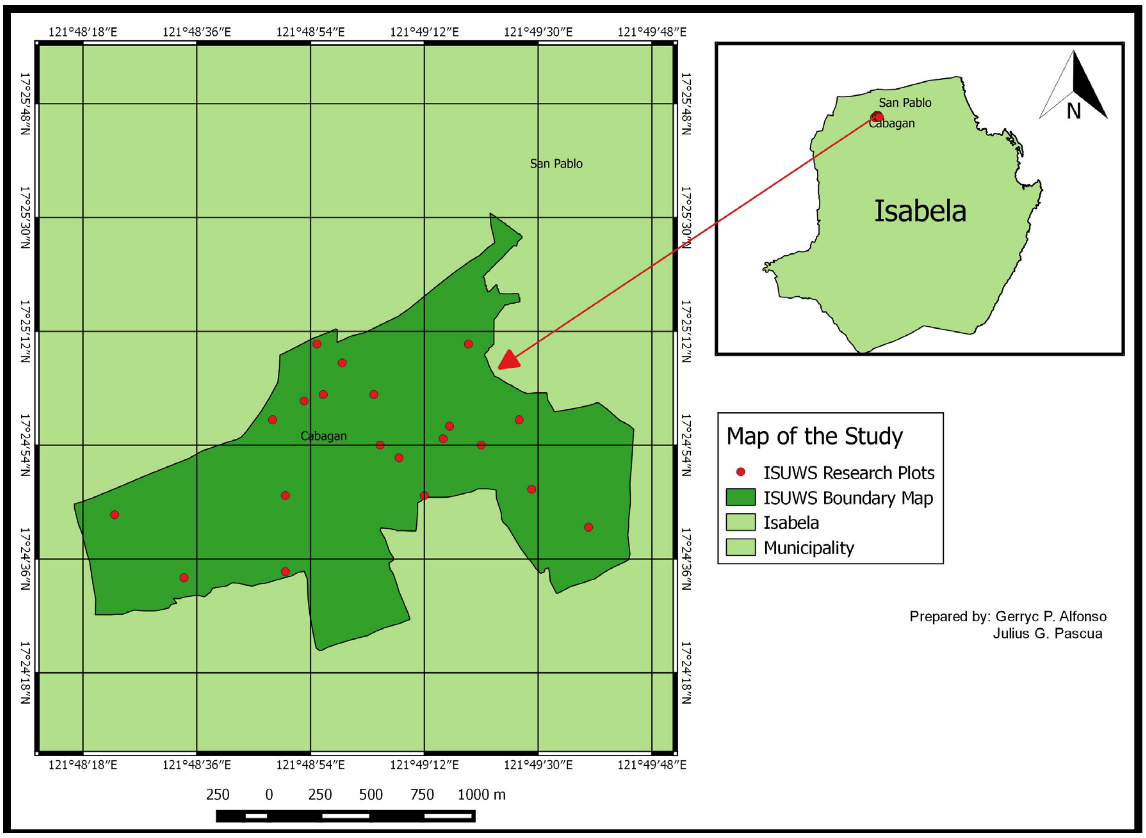

Figure 1. Location map of the study plots established at Isabela State University Wildlife Sanctuary.

in the southwest corner of the plots and oriented north-south as followed from Condit [7]. Within each sample plot, all trees having 10 cm and above in diameter at breast height (dbh) were recorded as followed from Brown (1997) [13].

3.3. Survey and Data Collection Procedure

The data gathered in this study was the dbh of every individual tree species. The dbh of every tree sample was measured at 1.3 m above the ground [15]. For forking trees below breast height, the dbh were taken and treated individually (plate 3). The dbh of a leaning tree was taken along its lower side, not the upper [7].

3.4. Data Analysis

The allometric equation developed by Banaticla was adopted to determine the above-ground biomass (AGB) of the tree species (Equation (1)) [10]. The carbon stock of the tree was determined by multiplying the computed AGB to 45% (Equation (2)) which is the average carbon content of wood samples collected from secondary forests from several locations in the Philippines [12]. The weight of CO2 sequestered was determined by multiplying the carbon stock of the tree to 3.67 (Equation (3)) which is the ratio of carbon to carbon dioxide [16].

Equation (1). Determination of above-ground tree biomass [10].

$$Y\ (\text{kg}) = 0.342 * (\text{dbh})\ 2.073 \quad (1)$$

where: Y = the above-ground biomass in kg.

dbh = the measured diameter at 1.3 m above the ground in cm.

Equation (2). Determination of Carbon Stock [12].

$$C = AGB * 45\% \quad (2)$$

where: C = carbon stock

AGB = computed above-ground tree biomass

45% = carbon content of tree biomass

Equation (3). Determination of CO_2 Sequestered [16].

$$CO_2 = C * 3.67 \quad (3)$$

where: CO_2 = carbon dioxide sequestered by tree species

C = carbon stock of tree species

3.67 = ratio of CO_2 to C

4. Results and Discussion

4.1. Tree Species in ISUWS

The 20 sample plots established within the study area were covered with different vegetation such as grasses and patches of forests (natural and manmade). The emphasis of this study is the tree covers where the tree species were identified and the number of individuals were counted. The 20 sample plots were covered with 34 tree species with an individual average number of 14.25 or a total of 285 individual trees. Table 1 shows the different tree species with their common name and their corresponding scientific name, number of individual trees and the plots where they were found. In the study it was found out that. ISUWS also homes some of Native endangered species.

Table 1. Tree species found in ISUWS.

Common Name	Scientific Name	No. of Trees	Plot Occurrence/s
1. Narra	*Pterocarpus indicus*	12	1
2. Mahogany	*Swietenia macrophylla*	13	1, 3, & 15
3. Fringon pula	*Bauhinia purpurea*	4	1, & 6
4. Binayuyu	*Antidesma ghaesembilla*	10	1, 15, & 16
5. Ipil-ipil	*Leucaena leucocephala*	5	1, 8, 11, & 15
6. Pagsahingin	Canarium asperum	36	2, 4, 5, 8, 12, 15, & 20
7. Kamiring	Semecarpus cuneiformis	68	2, 4, 8, 11, 12, 15, 18, & 20
8. Alim	Melanolepis multiglandulosa	15	2, 4, 11, & 15
9. Sablot	Litsea glutinosa	19	2, 4, 5, 14, 15, 16, 18, & 20
10. Banato	Mallotus philippensis	9	2, 15, 16, & 18
11. Alagaw	Premna odorata	8	2, 5, & 11
12. Niyog-niyogan	Ficus pseudopalma	2	2,
13. Dita	Alstonia scholaris	3	2, 4, & 9

Continued

14. Bagras	*Eucalyptus deglupta*	23	3, & 16
15. Anchoan dilaw	*Senna spectabilis*	5	3
16. Palosanto	*Triplaris cumingiana*	1	3
17. Manalu	*Semecarpus longifolius*	6	5, & 12
18. Kalios	*Streblus asper*	3	5, & 8
19. Kalumpang	*Sterculia foetidia*	1	5
20. Takulau	*Miliusa vidalii*	1	5
21. Japanese acacia	*Acacia auriculiformis*	2	6
22. Yemane	*Gmelina arborea*	14	6, 7, 14, 15, & 20
23. Neem tree	*Azadirachta indica*	2	6, 16
24. Binunga	*Macaranga tanarius*	6	6, 11, & 14
25. Balinghasai	Buchanania arborscens	4	8, 12, & 15
26. Uas-puas	Harpulia arborea	3	8, 20
27. Hauili	*Ficus septica*	2	9
28. Kahoy dalaga	*Mussaenda philippica*	1	9
29. Bolong-eta	*Diospyros pilosanthera*	2	11
30. Bulala	*Nauclea orientalis*	1	11
31. Duhat	*Syzygium cumini*	1	11
32. Anubing	*Artocarpus ovatus*	1	12
33. Rain tree	*Samanea saman*	1	18
34. Salingkogi	*Albizia saponaria*	1	20
	Total	285	

4.2. AGB of the Tree Species in ISUWS

Biomass was used to provide an estimate of the carbon reservoirs in ecosystems based on the fact that about half of it is Carbon [13]. Biomass density (expressed as dry matter per unit area) indicates the potential amount of CO_2 that can be released to the atmosphere when vegetation is burned or cleared [8]. **Table 2** shows the total above-ground biomass (AGB) of the selected tree species at ISUWS is 105.56 t/ha. The ABG of ISUWS is slightly lower than some of the secondary forest in the Philippines such in Cebu City with ABG of 195.13 t/ha [17] and Mindanao with ABG of 262 t/ha [14]. While in Kaliwa Watershed the computed AGB densities of secondary forests were 149.70 t/ha [18].

Among the 34 individual species, *Alstonia schloris* contains the largest amount of AGB with a mass of 20.97 t/ha followed by *Samanea saman* with the mass of 13.40 t/ha. The study of Udayakumar *et al.* [19] shows that *Samanea saman* contains 2.16 t/tree of AGB while the study of Marak *et al.* [20] shows that the AGB of *Alstonia scholaris* is 4.42 t/ha. The result of this study may be affected by their diameter as the both species belong to the highest diameter class. According to Guiabao [13], while the diameter of trees increases, the AGB also increases respectively.

Table 2. Calculated above-ground biomass (AGB) of selected tree species.

Scientific Name	ABG kg/Sp.	ABG (t ha^{-1})
1. *Alstonia scholaris*	838.95	20.97
2. *Samanea saman*	535.90	13.40
3. *Gmelina arborea*	361.24	9.03
4. *Eucalyptus deglupta*	295.09	7.38
5. *Canarium asperum*	385.43	9.64
6. *Semecarpus cuneiformis*	327.43	8.19
7. *Acacia auriculiformis*	233.80	5.84
8. *Acacia auriculiformis*	206.31	5.16
9. *Semecarpus longifolius*	172.58	4.31
10. *Litsea glutinosa*	133.06	3.33
11. *Swietenia macrophylla*	83.10	2.08
12. *Mallotus philippensis*	77.37	1.93
13. *Macaranga tanarius*	59.80	1.49
14. *Melanolepis multiglandulosa*	57.70	1.44
15. *Pterocarpus indicus*	53.88	1.35
16. *Sterculia foetidia*	48.94	1.22
17. *Harpulia arborea*	44.78	1.12
18. *Premna odorata*	44.11	1.10
19. *Leucaena leucocephala*	37.07	0.93
20. *Buchanania arborscens*	35.75	0.89
21. *Senna spectabilis*	34.65	0.87
22. *Streblus asper*	31.82	0.80
23. *Nauclea orientalis*	28.13	0.70
24. *Miliusa vidalii*	22.84	0.57
25. *Antidesma ghaesembilla*	15.11	0.38
26. *Ficus septica*	12.17	0.30
27. *Ficus pseudopalma*	5.71	0.14
28. *Diospyros pilosanthera*	9.70	0.24
29. *Syzygium cumini*	8.16	0.20
30. *Azadirachta indica*	7.41	0.19
31. *Mussaenda philippica*	4.43	0.11
32. *Albizia saponaria*	4.25	0.11
33. *Triplaris cumingiana*	3.54	0.09
34. *Artocarpus ovatus*	2.11	0.05
Total	4222.30	105.56

4.3. Calculated Carbon Stock of Tree Species at ISUWS

In general, the total carbon stock of tree species at ISUWS is 47.50 t/ha (**Table 3**). The carbon stock of the selected trees in the study is lower than the mean

Table 3. Calculated above-ground biomass (AGB) of selected tree species at ISUWS.

Scientific Name	Carbon Stock (kg/sp.)	Carbon Stock (t/ha)
1. *Alstonia scholaris*	377.53	9.44
2. *Samanea saman*	241.15	6.03
3. *Gmelina arborea*	162.56	4.06
4. *Eucalyptus deglupta*	132.79	3.32
5. *Canarium asperum*	173.44	4.34
6. *Semecarpus cuneiformis*	147.34	3.68
7. *Acacia auriculiformis*	105.21	2.63
8. *Acacia auriculiformis*	92.84	2.32
9. *Semecarpus longifolius*	77.66	1.94
10. *Litsea glutinosa*	59.88	1.50
11. *Swietenia macrophylla*	37.40	0.93
12. *Mallotus philippensis*	34.82	0.87
13. *Macaranga tanarius*	26.91	0.67
14. *Melanolepis multiglandulosa*	25.97	0.65
15. *Pterocarpus indicus*	24.24	0.61
16. *Sterculia foetidia*	22.02	0.55
17. *Harpulia arborea*	20.15	0.50
18. *Premna odorata*	19.85	0.50
19. *Leucaena leucocephala*	16.68	0.42
20. *Buchanania arborscens*	16.09	0.40
21. *Senna spectabilis*	15.59	0.39
22. *Streblus asper*	14.32	0.36
23. *Nauclea orientalis*	12.66	0.32
24. *Miliusa vidalii*	10.28	0.26
25. *Antidesma ghaesembilla*	6.80	0.17
26. *Ficus septica*	5.47	0.14
27. *Ficus pseudopalma*	4.36	0.11
28. *Diospyros pilosanthera*	3.67	0.09
29. *Syzygium cumini*	3.33	0.08
30. *Azadirachta indica*	2.57	0.06
31. *Mussaenda philippica*	1.99	0.05
32. *Albizia saponaria*	1.91	0.05
33. *Triplaris cumingiana*	1.59	0.04
34. *Artocarpus ovatus*	0.95	0.02
Total	1788.50	47.50

carbons stock (207.9 t/ha) of the following secondary forest: Makiling, Mindanao and Leyte [14]. On the other hand, the study on the carbon stock found in the reservation area of Kalinga State University shows a total of 475.25 t/ha [15]. Compared to other studies, the carbon content of the tree species at ISUWS is relatively lower. The primary reason is that some of the sampling plots don't have trees to measure. ISUWS have vast patches of forest stands but some of the areas are open.

4.4. Accumulated (CO_2) of Tree Species in ISUWS

The total amount of accumulated CO_2 of the tree species at ISUWS is 164.09 t/ha (**Table 4**). A total of 88.17 kt was observed to be the CO_2 sequestration capacity of the forest stand in the reservation area of JRMSU—Tampilisan campus [16]. The variation in the amount of CO_2 sequestered and stored in the species within the forest stand was affected greatly by the stand density of trees of their total population and the area planted to these trees, aside from their biomass [16].

Table 4. Accumulated (CO_2) of the selected tree species at ISUWS.

Scientific Name	Accumulated CO_2 (kg/sp.)	Accumulated CO_2 (t/ha)
1. *Alstonia scholaris*	1385.54	34.64
2. *Samanea saman*	885.02	22.13
3. *Gmelina arborea*	596.60	14.90
4. *Eucalyptus deglupta*	487.34	12.18
5. *Canarium asperum*	636.52	15.93
6. *Semecarpus cuneiformis*	540.74	13.51
7. *Acacia auriculiformis*	386.12	9.65
8. *Acacia auriculiformis*	340.72	8.51
9. *Semecarpus longifolius*	285.01	7.12
10. *Litsea glutinosa*	219.76	5.51
11. *Swietenia macrophylla*	137.26	3.41
12. *Mallotus philippensis*	127.79	3.19
13. *Macaranga tanarius*	98.76	2.46
14. *Melanolepis multiglandulosa*	95.31	2.39
15. *Pterocarpus indicus*	88.96	2.24
16. *Sterculia foetidia*	80.81	2.02
17. *Harpulia arborea*	73.95	1.84
18. *Premna odorata*	72.85	1.84
19. *Leucaena leucocephala*	61.22	1.54
20. *Buchanania arborscens*	59.05	1.47
21. *Senna spectabilis*	57.22	1.43
22. *Streblus asper*	52.55	1.32
23. *Nauclea orientalis*	46.46	1.17
24. *Miliusa vidalii*	37.73	0.95

Continued

25. *Antidesma ghaesembilla*	24.96	0.62
26. *Ficus septica*	20.07	0.51
27. *Ficus pseudopalma*	16.00	0.40
28. *Diospyros pilosanthera*	13.47	0.33
29. *Syzygium cumini*	12.22	0.29
30. *Azadirachta indica*	9.43	0.22
31. *Mussaenda philippica*	7.30	0.18
32. *Albizia saponaria*	7.01	0.18
33. *Triplaris cumingiana*	5.84	0.15
34. *Artocarpus ovatus*	3.49	0.07
Total	6563.80	164.09

5. Conclusion and Recommendation

Based on the study conducted, the 285 individual trees found at ISUWS contain a total of 105.56 t/ha of AGB. The estimated carbon stock of the trees in the area is 47.50 t/ha with 164.09 t/ha of accumulated CO_2. The researcher concluded that the tree species at ISUWS is lower than most of the secondary and urban forest in the Philippines but is still considerable to sequester high amount of carbon in the area. It was also concluded that the AGB was greatly affected by its diameter as this is the only data to estimate it. Based on the result and conclusion of this investigation, the following recommendations were drawn: Conduct a study concerning the carbon emission of the area to determine the relationship with its carbon sequestration potential and conduct tree planting activity to open areas in the study site to increase carbon stock potential and fully serve its purpose as a wildlife sanctuary.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

[1] Superales, J.B. (2016) Carbon Dioxide Capture and Storage Potential of Mahogany (*Swietenia macrophylla*) Saplings. *International Journal of Environmental Science and Development*, **7**, 611-614.

[2] Racelis, E.L., Carandang, E.R., Lasco, R.D., Racelis, D.A., Castillo, A.S.A. and Pulhin, J.M. (2008) Assessing the Carbon Budgets of Large Leaf Mahogany (*Swietenia macrophylla* King) and Dipterocarp Plantations in the Mt. Makiling Forest Reserve, Philippines. *Journal of Environmental Science and Management*, **11**, 40-55. https://worldagroforestry.org/publication/assessing-carbon-budgets-large-leaf-mahogany-swietenia-macrophylla-king-and-dipterocarp

[3] Vashum, K.T. and Jayakumar, S. (2012) Methods to Estimate Above-Ground Biomass and Carbon Stock in 578 Natural Forests—A Review. *Journal of Ecosystem*

and Ecography, **2**, Article No. 116. https://doi.org/10.4172/2157-7625.1000116

[4] Tandug, L.M. (2012) Aboveground Biomass and Carbon Stock Assessment of Forest Plantations in Mindanao. *The Technical Journal of Philippine Ecosystems and Natural Resources*, **22**, 1-28.

[5] Lasco, R.D. (2002) Forest Carbon Budgets in Southeast Asia Following Harvesting and Land Cover Change. *Science in China* (*Series C*), **45**, 55-64. https://www.researchgate.net/publication/254233911_Forest_carbon_budgets_in_Southeast_Asia_following_harvesting_and_land_cover_change

[6] Lasco, R.D. and Pulhin, F.B. (2003) Philippine Forest Ecosystems and Climate Change: Carbon Stocks, Rate of Sequestration and the Kyoto Protocol. *Annals of Tropical Research*, **25**, 37-51.

[7] Condit, R. (2008) Methods for Estimating Above-Ground Biomass of Forest and Replacement Vegetation in the Tropics. Center for Tropical Forest Science Research Manual, 73 p. http://ctfs.si.edu/Public/pdfs/CarbonInventoryMethods.pdf

[8] Ravindranath, N.H. and Ostwald, M. (2008) Methods for Estimating Above-Ground Biomass. *Carbon Inventory Methods*: *Handbook for Greenhouse Gas Inventory, Carbon Mitigation and Roundwood Production Projects*, Vol. 29, Springer, 113-147. https://www.springer.com/gp/book/9781402065460 https://doi.org/10.1007/978-1-4020-6547-7_10

[9] Woldemariam, T. (2015) GHG Emission Assessment Guideline Volume II: Above-ground Biomass Field Guide for Baseline Survey. Ministry of Agriculture, Federal Democratic Republic of Ethiopia, Addis Ababa.

[10] Banaticla, M.R.N., Sales, R.F. and Lasco, R.D. (2007) Biomass Equations for Tropical Tree Plantation Species in Young Stands Using Secondary Data from the Philippines. *Annals of Tropical Research*, **29**, 73-90. https://doi.org/10.32945/atr2937.2007

[11] Houghton, J.T., Meira Filho, L.G., Lim, B., Treanton, K., Mamaty, I., Bonduki, Y., Griggs, D.J. and Callander, B.A. (1997) Greenhouse Gas Inventory Workbook. Intergovernmental Panel on Climate Change (IPCC), Organization for Economic Co-operation and Development (OECD) and the International Energy Agency (IEA), Paris, 5.1-5.54.

[12] Lasco, R.D. and Pulhin, F.B. (2000) Forest Land-Use Change in the Philippines and Climate Change Mitigation. *Mitigation and Adaptation Strategies for Global Change*, **5**, 81-97. https://doi.org/10.1023/A:1009629220978

[13] Guiabao, E.G. (2010) Carbon Sequestration Potential of Tree Species in the Reservation Area of Kalinga State University. *International Journal of Interdisciplinary Research and Innovations*, **4**, 63-68.

[14] Zaragoza, M.G. (2016) Carbon Stock Assessment of Three Different Vegetative Covers in Kapatagan, Lanao del Norte, Philippines. *Advances in Environmental Sciences—International Journal of the Bioflux Society*, **8**, 205-220. http://www.aes.bioflux.com.ro/docs/2016.205-220.pdf

[15] Laguiwoy, D.G. (2010) Aboveground C Stock Assessment of Tree Stands at the Kalinga-Apayao State College Bulanao, Tabuk City, Kalinga.

[16] Tagupa, C., Lopez, A., Caperida, F., Pamunag, G. and Luzada, A. (2010) Carbon Dioxide (CO_2) Sequestration Capacity of Tampilisan Forest. *E-International Scientific Research Journal*, **2**, 182-191. https://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.683.2765&rep=rep1&type=pdf

[17] Pansit, N. (2015) Carbon Storage and Sequestration Potential of Urban Trees in

Cebu City, Philippines. *Mindanao Journal of Science and Technology*, **17**, 98-111. https://mjst.ustp.edu.ph/index.php/mjst/article/view/262/119

[18] Lasco, R.D., Pulhin, F.B. and Cruz, R.V.O. (2007) Carbon Stocks Assessment of Forest Land Uses in the Kaliwa Watershed, Philippines. *Journal of Environmental Science and Management*, **10**, 40-48. https://agris.fao.org/agris-search/search.do?recordID=PH2011000118

[19] Udayakumar, M., Selvam, A. and Sekar, T. (2018) Aboveground Biomass Stockpile and Carbon Sequestration Potential of *Albizia saman* in Chennai Metropolitan City, India. *Plant*, **6**, 60-66. https://doi.org/10.11648/j.plant.20180603.12

[20] Marak, T. and Khare, N. (2017) Carbon Sequestration Potential of Selected Tree Species in the Campus of Shuats. *International Journal for Scientific Research & Development*, **5**, 63-66. http://ijsrd.com/Article.php?manuscript=IJSRDV5I60049