INNSPUB

Journal of Biodiversity and Environmental Sciences (JBES)
ISSN: 2220-6663 (Print) 2222-3045 (Online)
Vol. 22, No. 6, p. 240-247, 2023
http://www.innspub.net

RESEARCH PAPER | OPEN ACCESS

Carbon sequestration potential of selected tree species in Bolila Malita, Davao Occidental Philippines

Cherizabel V. Madalmingan[1], Jhon Rey C. Caluboy[1], Leonel P. Lumogdang*[2]

[1]Department of Teacher Education, Institute of Teacher Education and Information Technology, Southern Philippines Agri-Business and Marine and Aquatic School of Technology (SPAMAST), Malita, Davao Occidental, Philippines

[2]Department of Marine Biology, Institute of Fisheries and Marine Sciences, Southern Philippines Agri-Business and Marine and Aquatic School of Technology (SPAMAST), Malita, Davao Occidental, Philippines

Article published on June 18, 2023

Key words: Carbon, Trees, Climate change, Sequestration, Mitigation

Abstract

This study determined the carbon sequestration potential of selected tree species in Bolila, Malita Davao Occidenta, Philippinesl. Twenty-seven (27) individuals trees were selected, measured, and calculated namely, Gmelina (*Gmelina arborea*), Mahogany (*Swietenia mahagoni*), Ipil-Ipil (*Leucaena leucocephala*), and Molave (*Vitex parviflora*) using line transect and non-destructive methods. Based on this results, Gmelina (*G. arborea*) has the highest potential of carbon sequestration potential. A total of 15,531 gram of Carbon in three transect lines compared to the Ipil-Ipil (*L. leucocephala*) has 2,667.12 gram Carbon, Molave (*Vitex parviflora*) has 1,778.08 gram of Carbon and Mahogany (*Swietenia mahagoni*) has 598.74 gram of Carbon. Moreover, the findings revealed that Diameter at Breast Height (DBH), Height, Green weight (GW), Dry weight (DW), and Carbon(C) stored have a significant effect on the carbon sequestration potential of trees. This study concludes that the selected tree species has the capability to sequester carbon. It is therefore recommended that the existing trees in Upper Timog must be preserved and restoration initiatives like planting trees should be considered as an important climate mitigation measure.

***Corresponding Author:** Leonel P. Lumogdang ✉ leonel.lumogdang@spamast.edu.ph

Introduction

Climate change is a global threat that needs immediate action from the global community. Carbon dioxide (CO_2) is one of the most abundant greenhouse gases and a primary cause of climate change. As climate change progresses, the search to offset greenhouse gas enrichment of the atmosphere intensifies (Folger, 2015).

Generally, the dangers brought on by rising global warming were known to involve, among other things other people, the results of heat waves, many severe occurrences (e.g., floods, and powerful typhoons, etc.), modifications in infectious diseases, the effects on food production, and freshwater supplies. Trees provide a significant ecological role by sequestering carbon and lowering vehicular emissions pollution. Planting has the potential to save up to 18kg CO_2/year in net carbon emissions for each tree. This advantage is equivalent to three to five forest trees of comparable size and health (Francesco, Ferrini, *et al.*, 2011).

Carbon sequestration is a process of transferring atmospheric CO_2 into long-lived global pools such as trees and has been considered an important natural strategy to combat climate change. Trees have been proven to reduce greenhouse gas concentration through the process of photosynthesis (Diamante, 2019). The quantity of carbon stored continuously by a tree grows significantly through time and age until the tree develops.

Locally, anthropogenic activities such as illegal logging, deforestation, and kaingin are rampant in barangay Bolila Malita Davao Occidental. As a result, the area experiences phenomena such as landslides and floods that are hazardous to the living. Thus, quantifying the carbon sequestration potential of trees is necessary to raise awareness of the residents the importance of trees and intensified awareness will act as a tool in addressing deforestation, illegal logging and other anthropogenic activities in a selected area for possible afforestation, illegal logging, and Kaingin. Moreover, this may also provide input to Barangay Local Government Unit and concerned authorities to implement further policies to conserve the existing trees and to plant more trees in Bolila, Malita Davao Occidental.

In addition, there is no information on carbon stock and sequestration potential of trees in the selected place. Hence, this study assessed the carbon sequestration potentials of selected tree species in Bolila, Malita Davao Occidental Philippines. This study surveyed the compositions of selected tree species in terms of; Diameter Breast Height, Height, Green Weigh, Dry Weight; and Carbon stored. Moreover, this study would determine the carbon sequestration potential of selected tree species. Lastly, to compare the selected tree species in every three (3) line transect according to their carbon sequestration potential.

Materials and methods

Research Locale

The study was conducted at Bolila Malita Davao Occidental Philippines. The two (2) most abundant tree species were selected in every line transect of Upper Timog (6 ° 23' North, 125 ° 34' East) Barangay Bolila, Malita Davao Occidental. The study site contains mini forest where different trees are located. Moreover, this site has not been studied, particularly, the dominant tree species' potential in sequestering carbon.

Establishment of study sites

In order to identify the carbon sequestration potentials of tree species, a non-destructive sampling design was utilized. In addition, the line transect method and purposive sampling method were applied for the selection of two (2) numerous species in every line transect. The non-destructive sampling method technique was used to evaluate and collect data without destroying it. It is commonly used for estimation of tree properties of the materials (Gorte, 2009). In addition, Line transect method was used in determining the dominant tree species. Line transect is a distance sampling method, widely used for estimating the abundance. Purposive sampling is also known as selective sampling where samples are selected on purpose.

The sampling site of 50 m by 50 m was divided into three (3) transect lines with an interval of 12.5 m. The dots represented trees and the arrows shows the bases of distance in getting samples. The trees that touch the lines and 1-5 meters from the line were counted. The trees were counted and two (2) numerous trees in every line transect was selected as a sample for the carbon sequestration estimations. The two (2) dominant tree species in every three (3) line transect were compared and measured.

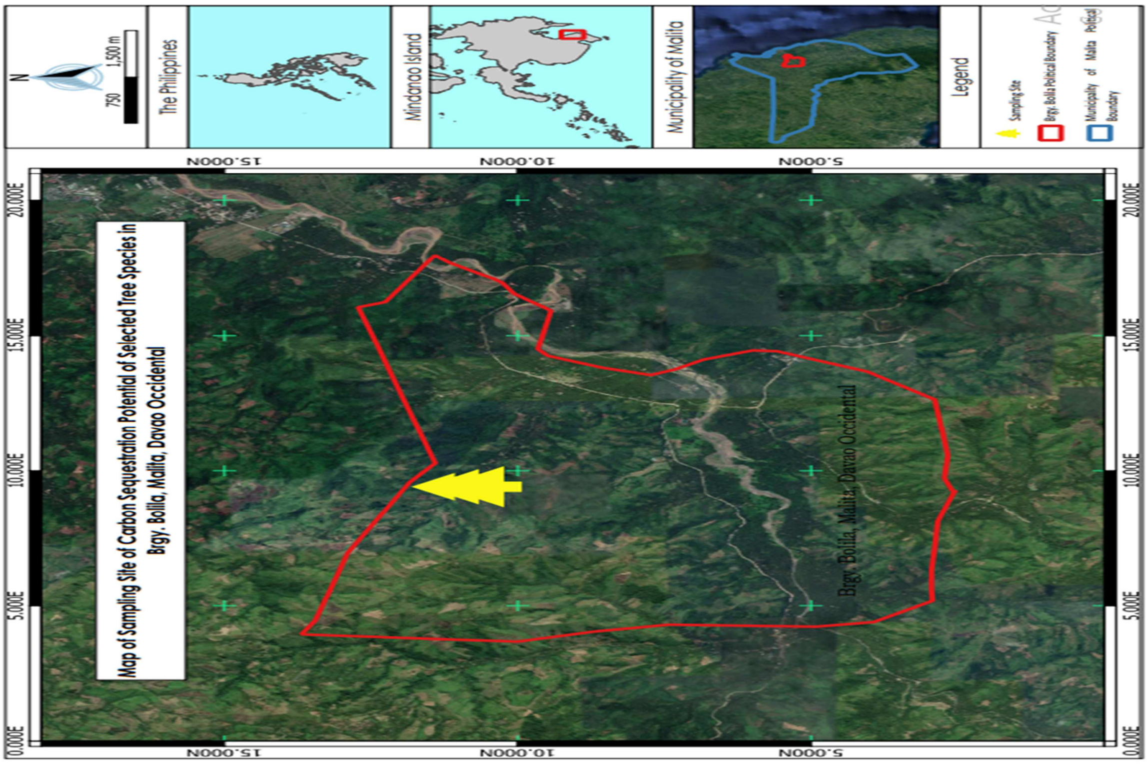

Fig. 1. Map of the study site.

Selection and Identification of Tree Species

Among the trees found in the Upper Timog, Bolila Malita Davao Occidental. The two (2) numerous species in the selected site were identified. The identification of the trees was based on Field Guide Book on Native Trees in the Philippines (Carig, 2020).

Data Gathering Procedure

The samples of the research were taken directly from the site, in Upper Timog, Bolila Malita Davao Occidental. Before conducting the study, the researchers submitted a letter request and endorsement letter for data gathering to the Dean of the Institute of Teacher Education and Information Technology (ITEIT) in SPAMAST. The signed endorsement letter and a letter request for approval were submitted to the office of the Department of Environment and Natural Resources (DENR). The letter request signed by the DENR was submitted to the office of the Barangay Captain in Bolila, Malita Davao Occidental and the researcher asked permission in surveying the trees through letter request. The said documents were shown to the owner of the lot and trees and the researchers asked an approval in studying the trees.

The carbon sequestration potentials of tree species were calculated individually using an algorithm for standing trees by Clark III. *Et al.* (1986), Brown (1997) and Racelis *et al.* (2008).

Measuring Tree Diameter

The circumference was measured using a measuring tape, approximately 1.4 meters above the ground. This was used to calculate the Diameter Breast Height of the tree.

Equation 1

$$DBH = C + \pi$$

Where:

DBH= Diameter Breast Height

C= circumference

Pi= 3.14

Measuring Tree Height

Trigonometry was used in calculating the tree height (h). Specifically, alternative clinometer and measuring tape were utilized in the study.

Equation 2

$$x = tan^0\ (Distance)$$

(x is the partial height of the tree)

$h = x + eye\ height$ (m)

Calculating Carbon Storage

Equation 3

1. Green Weight (GW)/above ground weight in pounds

For trees with diameter < 11 in

$$GW = 0.25 \times D^2 \times h$$

For trees with diameter > 11 in

$$GW = 0.15 \times D^2 \times h$$

The root system is about 20% of the above ground weight. Therefore, to determine the total green weight (Wtotal GW) of the tree, multiply the GW by 120%.

$$Wtotal\ GW = above\ ground\ weight \times 1.2$$

Equation 4

1. *Dry weight (DW) in pounds*

On average, experiments shows that a tree's dry matter is about 72.5% and 27.5% moisture. Therefore, to determine the DW, multiply the Wtotal GW of the tree by 72.5%.

$$DW = Wtotal\ GW \times 0.725$$

Equation 5

1. *Carbon Storage (C)*

From experiments of Southern Forests and Climate Change, scientists found out that about 50% of a trees dry weight is carbon. Therefore:

$$C = DW \times 0.5$$

Equation 6

Carbon sequestration Potential of Trees

CO2 sequestration was determined by multiplying C stored by 3.67 (Boomiraj *et al.*, (2021).

$$CO_2\ Seq. = C \times 3.67$$

Statistical Tools

One-way Analysis of Variance (ANOVA) was used to determine the significant differences between selected tree species according to their carbon sequestration potential. It is a statistical test used to analyze the difference between the means of more than two groups.

Results and discussion

A total of 27 trees were measured consisting of four (4) different species namely, Gmelina (*Gmelina arborea*), Mahogany (*Swietenia mahogany*), Ipil-Ipil (*Leucaena leucocephala*), and Molave (*Vitex parviflora*). In every three (3) transect lines, two (2) most numerous species are selected in a 50x50 meter area. *G. arborea* is present in all transect lines, *S. mahogany* is in the first transect line, *L. leucocephala* is in the second and lastly, *V. parviflora* is found in the third transect line. Table 1, 2, and 3 shows the mean of DBH of the four selected tree species. Mahogany *(S. mahogany)* has the highest DBH with 16.97 in transect In relation, to the study of Ali *et al.* (2010), they found that *S. mahogany* has a diameter at breast height ranging from 30 to 105 centimeters. Moreover, this result has similar findings with the study of Castillo & Miz (2014), the average DBH growth of Mahogany was 0.22cm yr-1, therefore, and they have concluded that management plans for the region assume mahogany will reach 55cm in DBH in 75 years.

Secondly, table 1, 2, and 3 shows the Height of four different species in every transect line. Gmelina *(G. arborea)* is the tallest with an average height of 18.21 which is found in transect 3, compared to the other trees. According to the study of Sharma *et al.*, (2021), *G. arborea* is a fast-growing tree species native to tropical and subtropical regions of Asia and Africa. It can grow up to 30 meters tall and with an average height of 12.7 meters. Moreover, in the study of Fern (2014), Gmelina is moderate to large in size that can reach a height of 3 to 30 meters and sometimes even taller.

Moreover, table 1, 2, and 3 shows the Green Weight of four different species in every transect line. Gmelina arborea has the highest tree green weight estimation, with an average of M=1.49 compared to the other trees. This result is supported by the study of Moya *et al.* (2013). Gmelina arborea has higher moisture content an average of 182% which concludes that *Gmelina arborea* has the highest green weight. Furthermore, in relation to the study of Kumar *et al.* (2011), they discovered that the average green weight of *Gmelina arborea* was 26.55kg. Trees between the ages of 5 and 6 had an average green weight of 74.33kg, which concludes that the green weight of Gmelina is high. Continuously, table 1, 2, and 3 shows the mean Dry weight of four different species in every transect line. *Gmelina arborea* has the highest tree dry weight estimation, with an average of 1.08 pounds which could be found in every transect line compared to the other trees. This result is supported by the study of Singh *et al.* (2021). They discovered that the average dry weight of *Gmelina arborea* trees after 24 months of growth was 7.36kg per tree, thus, *Gmelina arborea* has a high dry weight. Furthermore, Adekunle *et al.* (2018), concluded that *Gmelina arborea* trees may produce a high amount of biomass when grown under favorable climatic circumstances and with good management techniques, which results in high green weight and dry weight.

Lastly, table 1, 2, and 3 shows the mean of carbon stored by four different species in every transect line. The highest carbon stored gathered is 0.54 pounds of carbon stored in Gmelina arborea in transect 1. This aligns with the study of Bohre *et al.* (2012), who recommended that *Gmelina arborea* is a promising species for biomass and carbon accumulation, making it a potential candidate for restoring degraded ecosystems and serving as an effective carbon offset. Moreover, in relation to the study of Rasineni *et al.*, (2011), Gmelina's heights, number of branches and total biomass indicate that *Gmelina arborea* has a larger capacity to absorb carbon, which is an indicative of its effective carbon sequestration.

The findings revealed that the highest carbon sequestered by *G. arborea* was in three transect lines. It also has the highest mean (M= 1.99) in transect 1 (see Table 1). This is aligned to the study of Tamang *et al.*, (2021), that Gmelina has a higher capacity for carbon sequestration than other species. Moreover, it has the ability to significantly enhance carbon sequestration, when reached into maturity (Ruslim *et al.*, 2021).In addition, Jat *et al.* (2013) study also revealed that *Gmelina arborea* has an average yearly sequestration rate of 6.57 tonnes of carbon per hectare per year, which has a significant potential for carbon sequestration.

The *L. leucocephala* has the second high mean (M= 1.47) in transect 2 (see Table 2). This also aligns with the study conducted by Singh *et al.* (2019) in northern India; the authors investigated the carbon sequestration potential of *L. leucocephala* in agroforestry systems. The results showed that this tree species has a high potential for carbon sequestration, with an average annual sequestration rate of 3.62 tonnes of carbon per hectare per year.

The *V. parviflora* has the third high mean (M=1.31) in transect 3 (see Table 3). In relation to the study of Lasco *et al.* (2009), Molave forests in the Philippines have a carbon sequestration capacity of between 1.0 and 6.0 tonnes of carbon per hectare per year. Therefore, *Vitex parviflora* is reported as one of the tree species that have a high capacity to sequester carbon.

The *S. mahagoni* has the lowest carbon sequestered with a mean of (M=0.66) in transect 1 (see Table 1). In relation, to the study of Pascua *et al.* (2021) in Isabela State University, their study assesses the carbon sequestration of different species. The result shows that Mahogany has 2.08 tonnes of carbon per hectare per year.

Table 1. The mean of Diameter Breast Height, Height, Green Weight, Dry Weight, Carbon stored, and Carbon Sequestration of selected two (2) numerous tree species in every Transect line 1.

TRANSECT 1						
Species	Diameter Breast Height (in)	Height (m)	Green Weight (GW) in pounds	Dry Weight (DW) in pounds	Carbon Stored (C)	Carbon Sequestration (C seq)
G. arborea	0.55	12.46	1.49	1.08	0.54	1.99
S. mahagoni	16.97	8.24	0.50	0.36	0.18	0.66

Table 2. The mean of Diameter Breast Height, Height, Green Weight, Dry Weight, Carbon stored, and Carbon Sequestration of selected two (2) numerous tree species in Transect line 2.

TRANSECT 2						
Species	Diameter Breast Height (in)	Height (m)	Green Weight (GW) in pounds	Dry Weight (DW) in pounds	Carbon Stored (C)	Carbon Sequestration (C seq)
G. arborea	0.60	11.39	1.32	0.95	0.48	1.75
L. leucocephala	0.60	7.12	1.11	0.81	0.40	1.47

Table 3. The mean of Diameter Breast Height, Height, Green Weight, Dry Weight, Carbon stored, and Carbon Sequestration of selected two (2) numerous tree species in every Transect line 3.

TRANSECT 3						
Species	Diameter Breast Height (in)	Height (m)	Green Weight (GW) in pounds	Dry Weight (DW) in pounds	Carbon Stored (C)	Carbon Sequestration (C seq)
G. arborea	0.44	18.21	1.47	1.07	0.53	1.95
V. parviflora	0.47	9.88	0.98	0.72	0.29	1.31

Table 4 presents the analysis of variance for carbon sequestration potential of two selected trees in every three transects lines. In analyzing the data, Tukey HSD was used. The results show that *G. arborea* has the highest mean of 1.89. The P-value is 0.033 which is lower in the level of significance, resulting in the null hypothesis is being rejected which means that there is a significant difference of the selected tree species in every three (3) line transect according to their carbon sequestration potential. ANOVA revealed that the carbon sequestration potential of the selected trees in every transect line differ significantly. This also aligns with the study of Yeboah (2011), that there were notable differences in carbon sequestration and carbon content among species.

The results also revealed that *G. arborea*, *L. leucocephala*, and *V. parviflora* are comparable. This is due to their close value of the mean of Diameter Breast Height which affects the carbon sequestration potential of trees. Moreover, the results show that Species *G. arborea* and *S. mahagoni* has significant difference according to their carbon sequestration potential. This is due to the big gap between the mean in height and DBH. These results are supported by the study of Afzal and Mobeen (2013), that DBH, height, total biomass, and carbon storage are the factors that have a significant effect on carbon sequestration.

Table 4. Analysis of Variance for Carbon Sequestration.

Species	Mean	P-value	Decision
1. *G. arborea*	1.89	0.033	Reject hypothesis
2. *S. mahagoni*	0.22		
3. *L. leucocephala*	0.49		
4. *V. parviflora*	0.44		

Conclusion

Based on the results, Gmelina *(Gmelina arborea),* Mahogany *(Swietenia mahogani),* Ipil-Ipil (*Leucaena leucocephala)* and Molave *(Vitex parviflora)* have shown the ability to sequester carbon. A total of 20,574.95 grams of carbon were sequestered by the selected trees in three transect lines. Moreover, *G. arborea* has the great potential among the selected trees in carbon sequestering while *S. mahogani* has the lowest potential in sequestering carbon among the selected tree species.

Moreover, the results revealed that the selected tree species has significant difference according to their carbon sequestration potential.

In addition, the results also show that Gmelina, Ipil-Ipil, and Molave are comparable in their ability to sequester carbon. Thus, we can conclude that DBH, Height, Green Weight, Dry Weight, and Carbon stored affect carbon sequestration. In addition, this study supports that the selected trees found in Timog, Bolila Malita Davao Occidental have the ability to sequester carbon and may be used for afforestation. These findings can be used as basis for selecting appropriate tree species for tree planting activity program.

References

Adekunle, Egbetokun, Ademuluyi. 2018. Influence of Soil Nutrients on Biomass Production and Nutrient Uptake of *Gmelina arborea* (Roxb.) in Ondo State, Nigeria. Journal of Agriculture and Ecology Research International **16(4),** 1-8.

Afzal, Mobeen. 2013. Factors affecting carbon sequestration in trees. Research Officer, Punjab Forestry Research Institute, Faisalabad, Pakistan.

Ali HM, El-Mahrouk El-Sm, Hassan FA, El-Tarawy MA. 2011. Usage of sewage effluent in irrigation of some woody tree seedlings. Part 3: *Swietenia mahagoni* (L.) Jacq. Saudi J Biol Sci. Apr **18(2),** 201-7.

Bohre P, Chaubey OP, Singhal PK. 2012. Biomass Accumulation and Carbon Sequestration in *Dalbergia sissoo* Roxb. International Journal of Bio-Science and Bio-technology **vol. 4, no.3,** pp. 29-44.

Brown S. 1997. Estimating Biomass and Biomass Change of Tropical Forest: A Primer. Forestry Paper 134. For the Food and Agriculture Organization of the United Nations. Rome. FAO Forestry Paper- 134. ISBN 92-5-103955-0. Rome, Italy: UN-FAO. 55 pp.

Carig ET. 2020. Field Guidebook on Native Trees within the Quirino Forest Landscape. https://forestfoundation.ph/wp-content/uploads/2020/08/Field-Guidebook-on-the-Native-Trees-within-the-Quirino-Forest-Landscape.pdf

Castillo CW, Miz, PN. 2014. Fundamental Research Mahogany Growth and Mortality and the Relation of Growth to Site Characteristics in a Natural 60(5):907–913.

Clark A, Saucier JR, Henry MW. 1986. Total-Tree Weight, Stem Weight, and Volume Tables for Hardwood Species in the Southeast. Research Division, Georgia Forestry Commission. https://frames.gov/documents/jfsp/biomass_review/clark_saucier_mcnab_1986.pdf

Diamante C, Barre C, San Juan FM. 2019. Carbon sequestration potentials of tree species in an upland ecosystem in Zamboanga City, Mindanao, Philippines. Ciencia **38,** 97-107.

Fern K. 2023. Tropical Plants Database Retrieved: tropical.theferns.info.URL:tropical.theferns.info/viewtropical.php?id=Gmelina%20arborea&fbclid=IwAR1AbQOrBOcCq7IbPTqHzx1sd9z_BsJlGTbPJpu5p70B0odVyd62-WxNzoI.

Ferrini F, Fini A. 2011. Sustainable management techniques for trees in urban areas. Journal of Biodiversity and Ecological Sciences JBES. 1 (1):1-20

Folger P. 2015. Carbon capture and Sequestration: Research, Development, and demonstration at the U.S Department of Energy. Congressional Research Service

Gorte RW. 2009. Specialist in Natural Resources Policy, Carbon sequestration in forest. https://files.ethz.ch/isn/114913/2008_08_ClimateChange_Intl_Deforestation

Jat, Khatri, Tomar J. 2013. Carbon Sequestration Potential of Gmelina arborea Roxb. In Agroforestry Systems. Journal of Sustainable Forestry **32(4),** 330-344.

Kumar BM, Nair PKEDS. 2011. Carbon sequestration potential of agroforestry systems: Opportunities and challenges. Advances in Agriculture **8,** 1-307.

Lasco RD, Pulhin FB. 2009. Carbon budgets of forest ecosystems in the Philippines. Journal of Environmental Science and Management **12(1),** 1-13

Moya RR, Muñoz FA. 2013. Wet pockets in *Gmelina arborea* (Roxb.) dried lumber in trees from fast growth plantation. J. Trop. Forest Sci. **20,** 48-56

Pascua, Alfonso, Galicia. 2021. Carbon Sequestration Potential of Tree Species at Isabela State University Wildlife Sanctuary (ISUWS), Cabagan, Isabela, Philippines. Open Journal of Ecology **11,** 462-473.

Racelis EL, Carandang WM, Lasco RD, Racelis DA, Castillo A, Pulhin JM. 2008. Assessing the Carbon Budgets of Large Leaf Mahogany (*Swietenia macrophylla* King) and Dipterocarp Plantations in MMFR. Journal of Environmental Science and Management **11(1),** 40-55.

Rasineni GK, Guha A, Reddy AR. 2011. Responses of *Gmelina arborea*, a tropical deciduous tree species to elevated atmospheric CO2: Growth, biomass productivity and carbon sequestration efficacy. Plant Science **181(4),** 428-438.

Ruslim Y, Sandalayuk D, Kristiningrum R, Alam AS. 2021. Estimation of Above Ground Biomass and carbon stocks of *Tectona grandis* and *Gmelina arborea* stand in Gorontalo Province, Indonesia. Biodiversitas **22,** 1497-1508.

Sharma R, Pradhan L, Kumari M, Bhattacharya P. 2021. Assessment of Carbon Sequestration Potential of Tree Species in Amity University Campus Noida. Environmental Sciences Proceedings **3(1),** 52.

Singh RP, Rawat AK, Kaurav AS, Dubey A. 2021. Biomass accumulation and carbon sequestration potential of three year old *Gmelina arborea* trees under agroforestry systems in the Central Himalaya. Current Science **120(3),** 397-404.

Singh, Kumar, Sharma. 2019. Carbon Sequestration Potential of *Leucaena leucocephala* (Lam.) de Wit: A Multipurpose Agroforestry Tree Species. International Journal of Forestry Research 1-9.

Tamang M, Chettri R, Vineeta Shukla G, Bhat JA, Kumar A, Kumar M, Suryawanshi A, Yadav KK, Yadav KK. 2021. Stand Structure, Biomass and Carbon Storage in Gmelina arborea Plantation at Agricultural Landscape in Foothills of Eastern Himalayas. Land. **10(4),** 387.

Yeboah D. 2011. Variation in carbon content of tropical tree species from Ghana. Masters thesis Michigan Technological University http://digit alcommo ns.mtu.edu/etds/161 Accessed September.