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Carbon sequestration capacity of *Swietenia mahagoni* King. in the Rajshahi University campus of Bangladesh

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Abstract

Swietenia mahagoni King is the most popular and important forest tree species in Bangladesh and its plantation is increasing at a geometrical rate due to its timber quality. The study set out to quantify the organic carbon of *Swietenia mahagoni* throughout a range of ages in the vicinity of Rajshahi University. Systematic sampling method was followed for selection of plots using Global Positioning Systems. Biomass and organic carbon of trees were estimated using Allometric equations. The present study revealed that the maximum aboveground biomass, belowground biomass and carbon values were 1100.80, 166.12 and 632.94 kg/tree in 50 years old plantations respectively. The lowest aboveground biomass, belowground biomass and carbon values were 166.12, 63.36 and 95.52 632.9 kg/tree in 15 years old plantations respectively. Biomass and organic carbon were significantly ($p<0.05$) differed in different ages of Swietenia mahagoni. The findings of the study revealed that mean organic carbon was 28.78 tha- 1 and the maximum value was 47.47 tha-1 in 50 years old trees and the lowest value was 14.81 tha- 1 in 15 years' old trees. Swietenia magahoni is the most important and well-known popular tree which is planted in the whole country of Bangladesh. The findings indicated that carbon sequestration capacity of *Swietenia mahagoni* was higher than other forest tree species. So, *Swietenia mahagoni* can be selected for massive plantations throughout the country and training up the planters for proper management and development.

Keywords*:* Allometric equations, age, biomass, organic carbon storage, global warming.

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Introduction

Carbon is the most important component of all living organisms which is found as biomass in the body. Actually, carbon is stored in different components of environment such as vegetation, oceans, and soils and geological substances (Dharmesh *et al.*, 2014). Carbon dioxide is converted into organic carbon through photosynthesis process and it is stored in different tissues of plant as aboveground and belowground biomass (Chavan and Rasal, 2012). In this case, plantation can play a vital role in sequestration of carbon (Resh *et al.*, 2002). Trees are the dominant sources of carbon sink in forest areas. On an average, trees can sequester 150-300 tCha-1 (Akter, 2011). According to Mani *et al.*, (2018), climate change is having a significant negative influence on Bangladesh. In Bangladesh, homesteads and village groves are home to around 150 different species of trees, according to multiple scientists (Das, 1990). The stand density, basal area, and tree diameter of 52 of these species are all higher than average (Baul *et al.*, 2021). In the words of Dixon *et al.*, (1994), tropical forests are crucial for sequestering CO_2 from the air. About two-thirds of all known species call tropical regions home (Ashton and Tyrrell, 2012), making them the most hospitable places on Earth. About 17.50% of Bangladesh's total land area is covered by forests, which span approximately 2.53 million hectares (Alamgir *et al.*, 2014). Forests of Bangladesh are degraded due to urbanization, land-use change and over exploitation (Hansen *et al.*, 2013). Planted forests are the main sources of forest assets in Bangladesh and their demand is increasing at a geometrical rate. For this reason, the Bangladesh government, non-government organizations and planters are also emphasized the planted forest for the restoration of ecological balance. Plantations play a crucial role in improving carbon storage and reducing global warming. In this case, plantation through *Swietenia mahagoni* is becoming popular due to its timber quality, survival capacity, adaptation, growth rate, carbon sequestration capacity etc. *Swietenia mahagoni* is native to South America, Mexico and Central America, but it was introduced from these countries and well adapted in the Philippines, Singapore, Malaysia, Indonesia, India and Bangladesh (Das and Alam, 2001). *Swietenia mahagoni* is planted throughout the country as roadside, homestead and forest species due to its timber quality. But the estimation of carbon storage of *Swietenia mahagoni* is essential for the implementation of massive plantation program in Bangladesh. The main aim of the study was to estimate carbon storage of *Swietenia mahagoni* which will be helpful to extend plantation and mitigate climate change. Therefore, the present study is an attempt to estimate carbon storage of planted *Swietenia mahagoni* in the Rajshahi University campus areas.

Materials and Methods

The location of the study area- The study was carried out in the Rajshahi University campus. The campus is located at Motihar Thana under Rajshahi district. The campus is situated about 5 km south of the Rajshahi town and nearby the Dhaka- Rajshahi Highway Road. The Rajshahi University campus lies between 24°37′45″-24°35′30″ North latitudes and 88° 63′70 ″-88° 60′ 40 ″ East longitudes (Figure-1). The elevation is about 22.01 meters above (MSL).

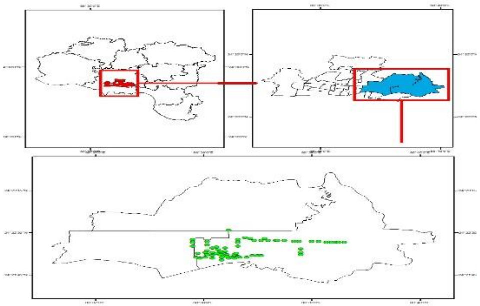

Figure-1. Map of the study area

Climatic condition- The study area is a tropical dry with low rainfall. The mean maximum and minimum temperature is 32.42° and 22.91°C respectively. The study area receives about 94.94 mm of precipitation and 127.54 days with rain. The average humidity is 59.11% and the driest, coldest, warmest and wettest months are December, January, April and July respectively (Weather Department, 2021).

Vegetation-The campus area is covered by various planted timber tree species. The planted species are mainly, Mangifera indica, Azadirachta indica, Swietenia mahagoni, Polyalthia longifolia, cocos, nucifera, Albizia lebbeck, Albizia richardiana, Lagerstroemia speciosa, Michelia champaca, Eucalyptus camaldolensis, Samanea saman, Artocarpus heterophyllus, Delonix regia, Caesalpinia pulcherrima and Citrus maxima etc. Besides, there are many kinds of indigenous and exotic species planted in the campus area. The campus of Rajshahi University falls under the tropical region and evergreen and semi-evergreen tree species are the dominant of the study area.

Selection of plots and sub-plots- The study was carried out in January 2022 to December 2022. The coordinated values were recorded using the Global Positioning System (GPS). The plots were selected using a systematic sampling strategy that made advantage of the globally known Global Positioning System (Pearson *et al.*, 2007). Each plot was 100 meters apart from each other. Four sub-plots (20 m radius) were set at the center of each plot. The total numbers of the plots were 156 (one hundred fifty six hundred twenty four) and sub-plots 616 (six hundred twenty six). Although Rana *et al.*, (2012) recommends a sampling intensity of 1%, this study used a sample intensity of above 20%. Each plot's total tree count was meticulously documented after careful counting and identification. At breast height (DBH), the trees were measured for both height and diameter. Marking and numbering each tree prevented any possibility of double counting. All of the trees in each plot had their DBH measured using a diameter tape, which is 1.30 meters above ground level. Trees with a diameter at breast height (DBH) of 5 cm or more were measured using a Hega-altimeter.

Estimation of trees biomass- To determine an individual tree's aboveground biomass, the allometric equations approach was employed. The Brown's model was used to determine aboveground biomass ((Brown *et al.*, 1989; Alves *et al.*, 1997; Brown, 1997; Schroeder *et al.*, 1997). This follow is a simulator for biomass that is located above ground.

$$AGB=\exp. \{-2.4090+0.9522\ln (D^2HS)\}$$

Where, AGB is the aboveground biomass (kg), H is the height of the trees (m), D is the diameter at breast height (cm), S is the wood density (kg /m3) for specific species (Sattar *et al.*, 1999).

Aboveground biomass per plot and per hectare were calculated by the following formulas:

AGB per hectare = Summation of AGB values of all the plots / total area of all plots ×10,000

BGB was considered to be 15 % of the aboveground biomass as suggested by Mac Dicken (1997).

The formula is given below:

BGB= AGB × (15 / 100)

The aboveground and belowground biomass was added to get the total biomass of a tree. Total biomass (TB) per plot and per hectare were calculated by the following formulas:

TB per plot = Summation of the total biomass values of all the trees in a plot.

TB= sum of total biomass values of all the plots/total area of all the plots×10,000

Data analysis- Descriptive statistics were calculated to describe biomass and carbon in trees. Analysis of Variance (ANOVA) was done at different age aspects. Duncan's Multiple Range Tests were used to determine significance the variation of the mean. Statistical Package for Social Science (SPSS) version 21 was used to perform these analyses.

Results and Discussion

The maximum aboveground biomass, belowground biomass and carbon values were 1100.80, 165.10 and 632.94 kg/tree in 50 years old plantation (Table -1). The lowest aboveground biomass, belowground biomass and carbon values were 166.12, 63.35 and 95.52 kg/tree in 15 years old plantation. The mean aboveground biomass and belowground biomass, total biomass and total carbon values were 642.11, 69.32, 738.43 and 184.61kg/tree in 15 to 50 years old plantation. Biomass and organic carbon were significantly ($p<0.05$) differed in different ages of *Swietenia mahagoni* in the study areas.

Table-1. Biomass and carbon stock of *Swietenia mahagoni* in different ages

Age (years)	**AGB ($kgtree^{-1}$)**	**BGB ($kgtree^{-1}$)**	**TB ($kgtree^{-1}$)**	**TC ($kgtree^{-1}$)**
50	1100.80±13.24	165.10±4.51	1265.89±12.34	632.94
40	885.84±10.29	132.90±6.87	1018.71±15.91	509.36
35	795.86±11.21	119.40±6.89	915.24±12.22	457.62
30	666.48±8.65	99.97±0.917	766.45±8.72	383.23
25	490.76±5.41	73.61±0.75	564.37±4.56	282.19
20	388.95±10.21	58.34±0.68	447.29±6.20	223.64
15	166.12±7.26	63.36±1.09	191.04±5.91	95.52
Mean	642.11	69.32	738.43	184.61

AGB=Aboveground biomass, BGB=Belowground biomass, TB=Total biomass, TC=Total carbon

Several scientists work on tree biomass and carbon in Bangladesh and reported that biomass and carbon were varied species to species. The maximum and the minimum values were 744.39 and 237.07 kg/tree found in Dipterocarpus turbinatus and Gmelina arborea respectively (Rahman *et al.,* 2021). Wide variation is found in biomass due to management, age, environment, and edaphic criteria. Carbon storage capacity of *Tectona grandis*, *Albizia lebbeck*, *Butea monosperma, Azadirachta indica* and *Eucalyptus citriodora* were 1.92, 2.42, 12.27, 3.35 and 1.81t/tree respectively in India (Suryawanshi *et al.,* 2014). The range aboveground biomass values were 9.36-306.01kg/tree for *Swietenia mahagoni* in Philippines (Kawahara *et al.,* 1981). It was also observed that the total aboveground biomass of Acacia auriculiformis ranged from 15.71 - 49.08 kg/tree and 9.18 - 68.58 kg/tree in Philippines (Buante, 1997). The present study indicated that the total aboveground biomass values were 1265.89 – 191.0 4 kg/tree which were better than other forest tree species. The mean aboveground, belowground and the total biomass values per hectare were 48.93, 8.63 and 57.56 t ha-1 at 15 to 50 years old plantations. The highest aboveground biomass was found in 50 years old trees and the lowest values was found in 15 years old trees. The ranges of total biomass were 94.94 - 29.62 tha-1 and their mean value was 57.56 tha-1. The present study revealed that mean organic carbon was 28.78 tha-1 and the maximum value was 47.47 tha-1 in 50 years old trees and the lowest value was 14.81 tha-1 in 15 years old trees (Table -2).

Table -2. Average aboveground biomass, belowground biomass, total biomass and carbon per hectare of Swietenia mahagoni

Age (yrs.)	AGB (tha^{-1})	BGB (tha^{-1})	TB (tha^{-1})	T Cha^{--1}
50	80.70	14.24	94.94	47.47
40	64.94	11.46	76.4	38.20
35	58.34	10.30	68.64	34.32
30	48.86	8.622	57.48	28.74
25	35.98	6.35	42.33	21.163
20	28.51	5.03	33.54	16.77
15	25.18	4.44	29.62	14.81
Mean	48.93	8.63	57.56	28.78

**AGB=Aboveground biomass, BGB = Belowground biomass, TB=Total biomass

Several scientists observed that (Rahman *et al.,* 2021) the range of aboveground biomass were 21.32 - 66.94 t ha-1 and belowground biomass values were varied from 2.20 - 6.92 t ha-1, while the total tree biomass per hectare of the six dominant forest tree species in their study area were 23.52 to 73.86 t ha-1. It was observed that mean aboveground biomass, belowground biomass and total biomass values were 37.73, 3.89 and 41.62 t ha-1 respectively. A study was conducted in the tropical deciduous and mixed deciduous forests and reported that average aboveground biomass values were 31.80, and 20.70 tha-1 (Salunkhe *et al.,* 2016). The aboveground biomass values were varied between 124.56 and 254.99 t ha-1. In this case, trees density were 128, 168 tree/ha respectively (Thokchom and Yadava, 2017). Normally, aboveground biomass values are depended on biotic and abiotic criteria such as soil fertility, topography etc. (Salunkhe *et al.,* 2016). The total biomass and carbon storage is depended on different factors such as; growth rate, age, species biotic and abiotic factors of environmental conditions etc. The above discussion indicated that carbon storage capacity of *Swietenia mahagoni* was the higher the high than other forest tree species.

Conclusion

Swietenia mahagoni is the most important and popular tree species in Bangladesh due to its durability. Its growth rate, wood quality and adaptation capacity are preferable to other tree species. *Swietenia mahagoni* can easily grow on poorly fertile soils whereas other forest species are disabled for growth and survival. The fixation capacity of carbon is higher and their fixed carbon stays a long time in the biomass because its maximum timber is used for making furniture. Fixation capacity of carbon is high and their fixed carbon stay a long time in the biomass because its maximum timber is used for making furniture. So this species can be planted in the massive plantation program in the whole country of Bangladesh.

Reference

Akter, S., (2011). Generation maps of forest carbon stock for management using Geographic Information Systems (GIS)., M.Sc. thesis. Institute of Forestry & Environmental Sciences. University of Chittagong, Chittagong, Bangladesh.

Alamgir, M. and Turton, S. M., (2014). Climate change and organic carbon storage in Bangladesh forests. In: Tuteja N, Gill SS, editors. Climate change and plant abiotic stress tolerance. Wiley-Blackwell, Weinheim, Germany, 881-902 pp.

Alves, D. S., Soares, J. V. S., Amaral, E. M. K., Mello, S. A. S., Almeida, O., Fernandes, S. and Silveria, A. M. (1997). Biomass of primary and secondary vegetation in Rondonia, Western Brazilian Amazon. Global Change Biol., 3(5): 451-462.

Ashton, M. S. and Tyrrell, M. L., (2012). Spalding D, Gentry B. Managing forest carbon in a changing climate. The Netherlands: Springer Science & Business Media. 397 pp.

Baul, T. K., Chakraborty, A., Nandi, R. *et al.,* (2021). Effects of tree species diversity and stand structure on carbon stocks of homestead forests in Maheshkhali Island, Southern Bangladesh. Carbon Balance Management, 16(11):175-181

Brown, S., Gillespie, A. J. and Lugo A. E., (1989). Biomass estimation methods for tropical forests with applications to forest inventory data. Forest Science, 35(4): 881-902.

Brown, S. (1997). Estimating biomass changes of tropical forests: a primer, FAO Forestry Paper 134 edn. Food and Agriculture Organization (FAO UN), Rome, Italy.

Buante, C. R., (1997). Biomass production of Acacia mangium Willd. Gmelina arborea Roxb and Acacia auriculiformis A. Cunn. & Benth .as fuel wood species in Leyte. Development In agroforestry Research, Book

Series No 160/ 1997, Philippine, Council for Agriculture, Forestry and Natural Resource Research and Development, Los Banos.

Chavan, B.L. and Rasal, G.B. (2012). Total sequestered carbon stock of *Mangifera indica*. Journal of Environment and Earth science, 2(1): 37-48.

Das, D.K., (1990). List of Bangladesh village tree species. Chittagong, Bangladesh, Forest Research Institute, 23:11.

Das, D. K. and Alam, M. K. (2001). Trees of Bangladesh. Bangladesh Forest Research Institute, Chittagong, Bangladesh. 342 pp.

Dharmesh, G.J., Vishant, R.M., Yogesh, B. P. and Himanshu, A. P., (2014). Carbon stock estimation major tree species in Attarsumba range, Gandhinagar forest division, India. Annals of Biological Research, 5(9): 46-49.

Dixon, R. K., Brown, S., Houghton, R. A., Solomon, A. M., Trexler, M.C., Wisniewski, J., (1994). Carbon pools and flux of global forest ecosystems. Science. 263:185–90.

Hansen, M. C., Potapov, P.V., Moore, R., Hancher, M., Turubanova, S. A., Tyukavina, A. Townshend, R. G., (2013). High-resolution global maps of 21st-century forest cover change. Science, 342(6160): 850-853.

Kawahara, T., Kanazawa, Y. and Sakurai, S., (1981). Biomass and net production of man-made forests in the Philippines. J. Jap. Fort. Soc., 63(9): 320-327.

Mac Dicken, K. G. (1997). A guide to monitoring carbon storage in forestry and agro forestryprojects USA. Winrock Int. Institute Agri. Development, P-19-99.

Mani, M., Bandyopadhyay, S., Chonabayashi, S., Markandya, A. and Mosier, T., (2018). South Asia's hotspots: The Impact of Temperature and Precipitation Changes on Living Standards. The World Bank, 1818 H Street NW, Washington, DC. 125pp.

Pearson, R. G., Raxworthy, C. J., Nakamura, M. and Pterson, A. T., (2007). Predicting species distributions from small numbers of occurrence records: a test case using cryptic geckos in Madagascar. Journal of Biogeography, 34 (1): 102–117.

Rana, B. S. Singh, S. P. and Singh, R. P., (2012). Biomass and net primary productivity in Central Himalayan forests along an altitudinal gradient. Forest Ecology and Management, 27(3-4): 199-218.

Salunkhe, O. Khare, P. K., Sahu, T. R. and Singh, S., (2016). Estimation of tree biomass reserves in tropical deciduous forests of Central India by non- destructive approach.Tropical Ecology, 57(2): 153-161.

Sattar, M. A., Bhattacharjee, D. K. and Kabir, M. F., (1999). Physical and mechanical properties and uses of timber of Bangladesh. Report 57, Seasoning and Timber Division, Bangladesh Forest Research Institute Chittagong, Bangladesh.

Schroeder, P., Brown, S., Mo, J., Birdsey, R. and Cieszewski, C., (1997). Biomass estimate for temperate broadleaf forests of the US using inventory data. Forest Science, 43(3):424-434.

Suryawanshi, M. N., Patel, A.R. Kale, S.T. and Patil, P. R., (2014). Carbon sequestration potential of tree species in the Environment of North Maharashtra University Campus Jalgaon, India. Bioscience Discovery, 5(2): 175-179.

Rahman, M. M. Rahman, S. H. and Al-Amin, M., (2021). Role of forest tree species in the carbon storage of the Kaptai National park, Bangladesh, Journal of Bangladesh Botanical Society, 50 (2): 365-371.

Resh, S.C., Binkley, D. and Parrotta, J. A., (2002). Greater soil carbon sequestration under Nitrogen-fixing trees compared with Eucalyptus species. Ecosystems, 5(3): 217-231.

Thokchom, A. and Yadava, P. S., (2012). Biomass and carbon stock along an altitudinal gradient in the forest of Manipur, Northeast India. Tropical Ecology, 58(2): 389-396.

Wilson, E.O., Peter, F.M., Raven, P.H., (1988). Our diminishing tropical forests. In: Wilson EO, Peter FM, editors. Biodiversity. Washington, DC