Estimation of the Aboveground Biomass of the Secondary Forest and Mango + Coconut Multistorey Agroforest Stand in Salikneta Farm using Four Allometric Equations

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Abstract: Global warming is one of the serious environmental problems of the current era because of the detrimental threats it can impose to the planet. One of its major culprits identified is the excessive emissions of greenhouse gases (GHGs) in the atmosphere, with carbon dioxide (CO_2) as the major concern since it is the most abundant among GHGs. In light of this global phenomenon, vegetation and land masses can act either as carbon source through the process of decomposition or as sink by absorbing CO_2 in the process of photosynthesis. Most of the studies done to determine the possible contribution of trees are to determine the carbon stocks in various pools available in a single standing tree including the leaves (aboveground) and root systems (belowground). This study was done to estimate and compare the aboveground carbon density of a secondary forest and mango + coconut multistorey agroforest stand inside Salikneta Farm-De La Salle Araneta University – Agrivet Science Institute in San Jose Del Monte, Bulacan. This was accomplished by measuring the diameter at breast height (dbh) and tree height of the different trees present in both sites. After which data collected where subjected to four allometric equations (1) Brown et al. (1997), (2) Banaticla et al. (2007), (3) Henry et al. (2011), and (4) Chave et al. (2005). Each of these equations requires a different set/s of variable/s which subsequently led to four different scenarios. Results showed that for Chave et al. and Henry et al. model, the secondary forest has higher estimates which could be associated to the number of parameters used in the equation. Despite this, ANOVA results showed that there is no significant difference between the two land-uses with regards total aboveground biomass. Given these findings, it is suggested that both stand should be conserved to maintain their contribution to carbon sequestration and mitigating climate change.

Key Words: Global warming; Biomass; Carbon sequestration; Carbon density; Allometric equation

1. INTRODUCTION

The phenomenon global warming has been considered as one of the most serious environmental problems of the present generation. Global warming is primarily caused by the uncontrolled emissions of greenhouse gases, with carbon dioxide considered as the most serious culprit [1]. Maintenance of normal CO_2 emissions would aid in preventing global warming from getting worst and detrimental. Forest ecosystem and other land-uses perform an important role in global warming by acting either as a source of or a sink for carbon [2]. As a source, trees can contribute to the amount of CO_2 in the atmosphere once the biomass is burned or start to decompose. As a sink, on the other hand, these trees absorb CO_2 from the atmosphere and use it for their growth and food production via photosynthesis. For a more realistic estimate of available carbon stored in tree biomass, destructive sampling must be done. However this would mean more CO_2 would be released in the atmosphere hence the development of allometric equations that use tree parameters like diameter at breast height (dbh), tree height and wood density [3]. Given these realities, the present study aimed to estimate and compare the total aboveground biomass of the two land-use systems inside Salikneta Farm-De La Salle Araneta University – Agrivet Science Institute in San Jose Del Monte, Bulacan in order to determine their potential contribution to the already established body of knowledge about the significant role of trees in global warming as well as to compare the different published allometric equations namely Brown et al. (1997), Banaticla et al. (2007), Henry et al. (2011), and Chave et al. (2005).

2. METHODOLOGY

A 1-hectare sample area was demarcated for the secondary forest and the mango (*Mangifera indica*) + coconut (*Cocos nucifera*) multistorey agroforest stand of Salikneta Farm. This was accomplished by superimposing numbered gridlines on images of the sites. A random number generator was used to determine the vertical and horizontal displacements of the starting point of the 1 ha plot (Figure 1a and Figure 1b).

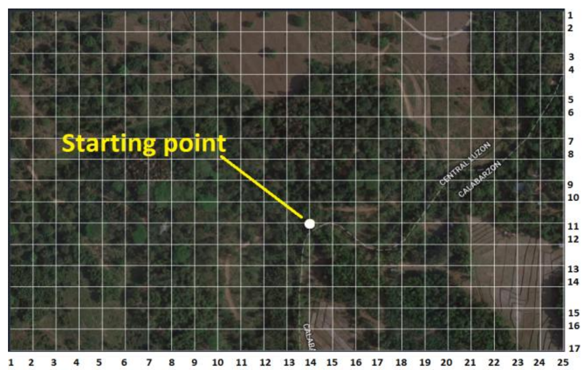

Figure 1a. Map showing the starting point of the 1 ha sampling plot in the secondary forest (Map source: Google Maps)

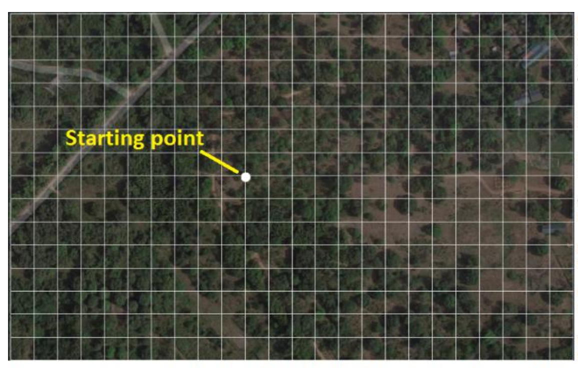

Figure 1b. Map showing the starting point of the 1 ha sampling plot in the agroforest stand (Map source: Google Maps)

In each of the sampling areas, a belt transect was established that traversed the south-west and north-east corners of the 1-ha plot. The belt transect had 10 quadrats that measured 10 x 10 m as shown in Figure 2.

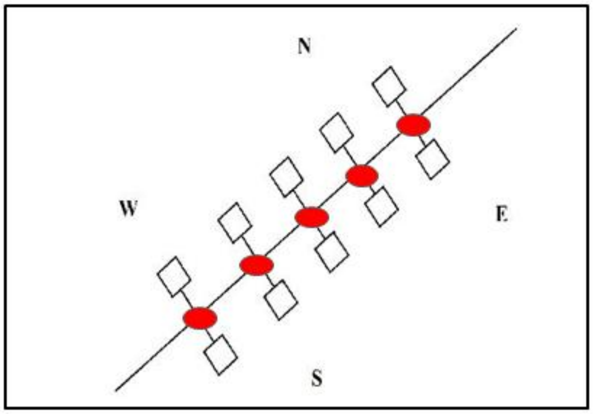

Figure 2. Diagrammatic representation of the belt transect laid inside the sampling areas

All trees with at least 5 cm dbh inside the quadrats of the belt transects were included in the measurements of dbh and height. The data gathered here were plugged into the different allometric equations published by Brown et al. (1997) (1), Banaticla et al. (2007) (2), Henry et al. (2011) (3), and Chave et al. (2005) (4) to estimate the aboveground biomass accumulated in both stands [4]-[7].

$$Y = e^{[-2.134+2.53\ln(DBH)]} \quad (1)$$

$$Y = 0.342 \; x \; (DBH)^{2.073} \quad (2)$$

$$Y = Volume\ Ave.\ x\ (0.62\ x\ 10^{3}) \quad (3)$$

$$Y = e^{[-2.977+\ln(\rho D^2 H)]} \quad (4)$$

3. RESULTS AND DISCUSSION

Each of the equations were developed using different data sets and regressions. Some of the equations used different parameters other than dbh and height. Therefore, this gave us a brief hint that the resulting computations from each equations would also vary. The models of Brown and Chave are both generalized/pantropic allometric equations (Litton and Kauffman, 2008). The Brown et al. (1997) model was based from regressions of existing volume data gathered from tree species of tropical America and some parts of Africa and Asia. This model requires only dbh as the parameter. Chave's equation was established by compiling data (dbh, height, wood density) from tree harvest studies across 58 different sites across the globe, each site having different climatic conditions. Data compiled were regressed to come up with the model. Their model uses dbh, height, and wood density. The models of Henry et al. (2011) and Banaticla et al. (2007) are relatively quite specific. The model of Henry et al. (2011) was made by compiling data (wood density and other available allometric equations) to create an equation to estimate biomass in sub-Saharan African forests. The highlight of this equation is the volume average. This is the average biomass of the tree parts (stump, branches, etc.). The model of Banaticla et al. (2007) was established from secondary data obtained via destructive sampling in different sites in the Philippines. The secondary data were subjected under regression to come up with their model. This equation uses only dbh as the parameter.

The results vary from one model to another as such four scenarios were presented (Table 1). One possible reason for this variation can be attributed to the number of tree allometric characteristics used in the equations. Brown et al.'s (1997) and Banaticla et al.'s (2007) equations include only dbh as their sole estimating parameter while Henry et al. (2011) included height and Chave et al. (2005) added wood density along with dbh and height.

Table 1. Total calculated aboveground biomass of the secondary forest and agroforest farm presented in four different scenarios.

Scenario/Equation Used	Aboveground Biomass (Mg)	
	Secondary Forest	Agroforest Farm
Brown et al. (1997)	46.862	62.252
Banaticla et al. (2007)	18.776	22.759
Henry et al. (2011)	28.669	11.291
Chave et al. (2005)	12.410	12.247

For both Brown et al.'s (1997) and Banaticla et al.'s (2007) equation, the results showed that the Ma+Co multistorey agroforest have a higher accumulated aboveground biomass with the values of 62.252 Mg and 22.759 Mg, respectively; compared to secondary forest with the values of 46.862 Mg and 18.776 Mg, respectively. However, for the equations of Henry et al. (2011) and Chave et al. (2005), the secondary forest have a higher aboveground biomass; having the values of 28.699 Mg and 12.410 Mg, respectively; against the Ma+Co multistorey agroforest stand with only 11.291 Mg and 12.247 Mg for both equations. Noting that dbh is the only parameter included in models of Brown et al. (1997) and Banaticla et al. (2007), it can be assumed that the trees in the Ma+Co multistorey agroforest have wider diameter than trees in the secondary forest. Furthermore, the inclusion of new parameters such as height and wood density adjusted the values for both stands and showed that the secondary forest have higher aboveground biomass; which also signifies that the trees were taller than in the agroforest. However, for all the scenarios created by the different allometric equations, statistical analyses showed that the two stands are not significantly different from one another in terms of aboveground biomass. The non-significant difference may be attributed to the close proximity between both stands wherein the location they were at did not became a factor to their biomass accumulation and carbon sequestration potential. In addition, related studies showed that the number of parameters is highly correlated to the accuracy of the model [8] therefore it can be assumed that Chave et al.'s (2005) equation is the most accurate although results are yet conclusive.

4. CONCLUSIONS AND RECOMMENDATIONS

Forest ecosystems can act either as source of or sink for carbon dioxide and other greenhouse gases (GHGs). As such, this study looked at the ability of the two land-uses inside Salikneta Farm namely, the secondary forest and mango + coconut multistorey agroforest stand, to sequester and store carbon in their biomass. Results showed variability in their total accumulated aboveground biomass using the four published allometric equations but was proven to be not significantly different from each other which can be attributed to the close proximity between the two stands approximated to have 250 m distance from each other and the similarities of the dominant vegetation.

This work is a part of the baseline study done to determine the total carbon density of the secondary forest and Ma+Co multistorey agroforest stand inside Salikneta Farm which focused only on the four different allometric equations used for estimating aboveground biomass. A follow-up study is recommended using the same site to confirm the findings or obtain better results on a long-term basis. A revised allometric equation that will consider more tree parameters will also be an ideal scenario to provide more realistic and accurate estimate of carbon stocks in any land-use.

5. ACKNOWLEDGMENTS

The researchers would like to thank the people of Salikneta Farm for the warm accommodation and allowing them to conduct this particular study. Among this people, special thanks to Sir Ariel Pelayo, a student/worker in Salikneta Farm in which his familiarity to the place helped the researchers in navigating through the forest, establishing the plots, and in identifying some of the tree species as well. Without his help, this study would not have met the timeframe the researchers have established. Special thanks as well to Dr. Renezita Sales-Come of Visayas State University for her invaluable suggestions and advises on the methodology and on how the results should be presented.

6. REFERENCES

Banaticla, R., Sales, R. F., & Lasco, R. D. (2005). Biomass Equations for Tropical Tree Plantations Using Secondary Data from the Philippines. *Annals of Tropical Research; Special Issue on Smallholder Forestry*, 113-128. Retrieved from https://espace.library.uq.edu.au/view/UQ:8632/n11_Banaticla_-_.pdf

Brown, S. (1997). Estimating biomass and biomass change of tropical forests: A primer. *Food* *and Agriculture Organization Forestry Paper 134*.

Burnham, K. P., & Anderson, D. R. (2010). *Model selection and multimodel inference: A practical information-theoretic approach*. New York: Springer.

Chave, J., Andalo, C., Brown, S., Cairns, M. A., Chambers, J. Q., Eamus, D., … Yamakura, T. (2005). Tree allometry and improved estimation of carbon stocks and balance in tropical forests. *Oecologia*, *145*(1), 87-99. doi:10.1007/s00442-005-0100-x

Henry, M., Picard, N., Trotta, C., Manlay, R., Valentini, R., Bernoux, M., & Saint-André, L. (2011). Estimating tree biomass of sub-Saharan African forests: a review of available allometric equations. *Silva Fennica*, *45*(3B). doi:10.14214/sf.38

Lasco, R., Guillermo, I., Cruz, I., Bantayan, N., & Pulhin, F. (2004). Carbon stocks assessment of a secondary forest in Mount Makiling Forest Reserve, Philippines. *Journal of Tropical Forest Science*, *6*, 35-45.

Litton, C. M., & Boone Kauffman, J. (2008). Allometric Models for Predicting Aboveground Biomass in Two Widespread Woody Plants in Hawaii. *Biotropica*, *40*(3), 313-320. doi:10.1111/j.1744-7429.2007.00383.x

Rohrer, J. (n.d.). Time for Change. Retrieved from timeforchange.org/CO2-cause-of-global-warming

Smith, B., & Brand, G. (1983). Allometric biomass equations for 98 species of herbs, shrubs, and small trees. *Research Note NC-299*.