Indigenous Tree Species Carbon Trapping Potentials

Onofre S. Corpuz and Z.M. Adam

***Abstract*—The study estimated the potentials of the selected indigenous tree species in Central Mindanao in trapping carbon. Field sampling and measurement of benguet pine (Pinus kesiya Endl.), white lauan (Shorea contorta Vid..), dao [Dracontomelon dao (Blanco) Merr. & Rolfe], and almaciga (Agathis philippinensis) diameter breast height (dbh) and height had been done within an established 200m2 plot per plantations to obtain data for biomass estimation of each plantation species. Results shows that Pinus kesiya at plantation age 11 has the greatest biomass production of 1,831.47Mt/ha as compared to Shorea contorta Vid.. (1,301.37Mt/ha); Dracontomelon dao (Blanco) Merr. & Rolfe. (922.99Mt/ha); and Agathis philippinensis Warb (895.79Mt/ha). The carbon trapped by benguet pine in 11 years amounts to 824.16Mt/ha with average carbon sequestration of 74.92Mt/ha/year which is 69% greater than white lauan (25 years), 73% greater than almaciga (20 years), and 60% greater than dao (14 years) plantations. The higher amount of carbon sequestered by benguet pine is due to its faster growth as compared to the other species studied as evident of its bigger mean dbh class of 16.5–31 cm and so it has higher biomass and hence, higher C sequestration ability. These fast growing species should be used in reforestation and afforestation projects to mitigate climate change through carbon sequestration.**

***Keywords*— Below Ground Biomass, Above Ground Biomass, Carbon Density, Indigenous Tree, Cotabato, Bukidnon.**

I. INTRODUCTION

Climate change is a global issue that affects people and the environment. Many elements of human society and the environment are sensitive to climate variability and change, such as agriculture, natural ecosystems, coastal areas, and heating and cooling requirements. Climate change is a security problem in as much as the kinds of environmental changes that may result pose risks to peace and development .

Over 100 years ago, people worldwide began burning more coal and oil for homes, factories, and transportation. Burning these fossil fuels releases carbon dioxide and other greenhouse gases into the atmosphere. These added greenhouses gases have caused Earth to warm more quickly than it has in the past.

One way of mitigating climate change is to plant more trees that will absorb carbon dioxide in the atmosphere. Such activities are an assured undertaking that oppresses negative effect of climate change . According to Trexler and Haugen 1995, forest ecosystems play an important role in climate change because they can be both sources and sinks of CO2. At present, the world's tropical forests are found to be a net source of Carbon due to anthropologic activities including deforestation with an emission of 1.6 Gt (1 Gt = 109 tons), in the year 1990 alone (Sales et al. 2005). In fact, Philippine forests, through massive deforestation, were found to have contributed about 3.7 Pg (1 Pg = 1015 tons) of C to the

atmosphere from year 1500 to the modern era (Lasco and Pulhin 1999). Other causes could be mainly human-induced activities including fossil fuel burning and changes in land use and land cover (IPCC 1996). Estimation of carbon stocks of tree plantations is necessary to provide reliable estimates and inputs to national inventories of greenhouse gas emissions (GHGs) . Carbon stocks can be determined through destructive sampling and field measurement . There are techniques and methods for sampling design and methods that accurately and precisely measure carbon pools, that can be chosen based on commonly accepted principles of forest inventory, soil sampling and ecological surveys (Mac Dicken 1997).

Forest offers many strategies to address climate change. The United Nations Framework Convention on Climate Change (UNFC) articulates two approaches for addressing climate change: mitigation (i.e., reducing emissions and increasing carbon sequestration) and adaptation (i.e., adjusting to the already changing climate). Furthermore, almost all carbon studies/projects to date have targeted either publicly owned reforestation areas or private plantations.

The rehabilitation of degraded lands through the establishment of tree plantations and agroforestry play an important role in storing carbon by sequestering CO2. These strategies have become popular in many places due to a combination of economic return and the environmental benefits they provide (Aggangan, 2001); however, there is little information on the carbon budgets of tropical tree plantations and tree farms. This information is needed for a more accurate

picture of their role in mitigating climate change. This present study however attempted to determine the potentials of selected indigenous tree species in Central Mindanao in mitigating climate change through estimation of the amount of carbon stored in the plantations through field sampling and measurement.

This study aimed to determine the potentials of the selected indigenous tree species such as white lauan (Shorea contorta Vid.), almaciga (Agathis philippinensis Warb), dao [Dracontomelon dao (Blanco) Merr. & Rolfe], benguet pine (Pinus kesiya Endl.) in mitigating climate change through carbon sequestration. Specifically, it sought to:

1. Estimate the below and above ground biomass of the

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selected indigenous tree species in Cotabato and Bukidnon Philippines.

2. Calculate the amount of carbon sequestered by the plantation through field measurement and modeling.

3. Relate carbon pools such as below and above ground biomass with total carbon stored by each tree plantation species.

II. CONCEPTUAL FRAMEWORK

Estimation of the amount of carbon storage in each indigenous tree plantation (white lauan, almaciga, dao and benguet pine) were done through field sampling and measurements. Carbon density were estimated using biomass equations. Soil organic carbon were also taken, multiplies the derived biomass by 45% default values as suggested by IPCC.

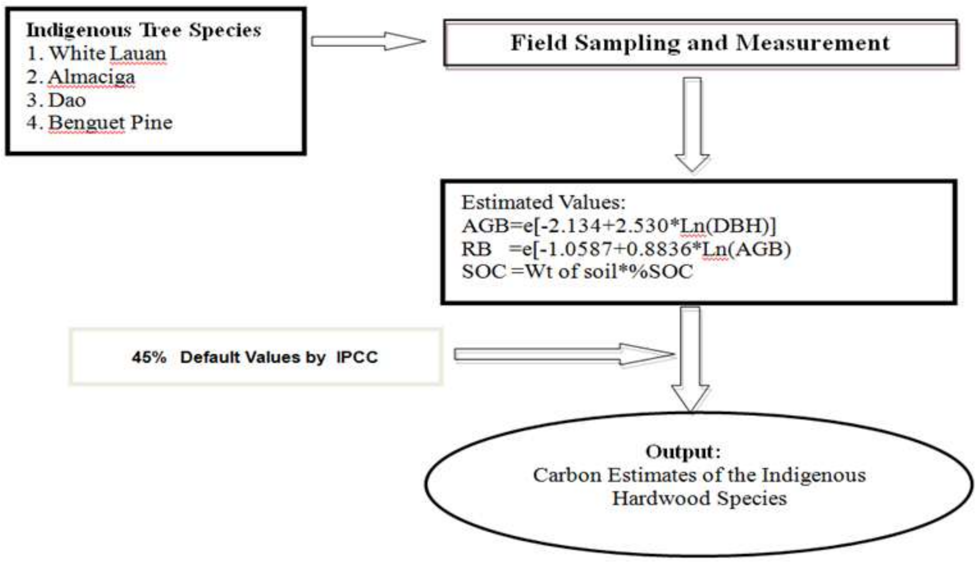

Figure 1. Conceptual framework of the study.

III. MATERIALS AND METHODS

In order to obtain important data, the following materials were used: 10m x 20m twine for 200m2 plot. Tree caliper in measuring diameter breast height (dbh).Abney hand level, meter tape, calibrated bamboo pools in measuring tree height and improvised tin can in getting soil samples for soil organic carbon (SOC) analysis.

IV. METHODOLOGY

This study was conducted on April 14 to May 20, 2011 at Arakan Cotabato ($07^{0}20.69$'N and $125^{0}05$'E, 148m asl) and CEDAR project in Imapasug'ong Bukidnon . A White lauan, dao, almaciga and benguet pine plantations have been used in the study. One 10m x 20m plot (200 sq.m) was established per plantation for the tree samples measuring tree diameter (cm) and heights (merchantable and total height) in meters. Two subplots (1m x 1m) were also established per plantation for the ground samples such as: fallen leaves, grasses, twigs, soils for the soil organic carbon estimation taken by driving an improvised canister in the soil, and other ground debris.

The following major data were measured: a). diameter breast height (DBH) measured at 1.3m above the ground; b). total tree height; c). merchantable height (MH); d). above-ground biomass (AGB) computed using the allometric equation by Brown. 1997 which is AGB = exp {-2.134 + 2.530*ln(DBH)}; e). Root biomass by Cairns et.al. 1997 which is RB = e[-1.0587 + 0.8836*ln(AGB); f). Ground biomass (GB); g). Tree volume (V) = $0.7854(d)^2$MH/TH(form factor) where Form factor=merchantable volume/basal area at breast heigh; g). basal area (BA) = $0.7854(D)^2$; h). biomass density= AGB + RB + GB; i). carbon density = biomass density x 45% carbon content as suggested by IPCC 1996.

The soil organic carbon storage was computed using the following formula:

$$\text{Bulk Density } (g\ cc^{-1}) = \frac{\text{dried weight of soil}}{\text{Soil volume}} \quad \text{(Equation 1)}$$

Soil Organic Carbon (SOC) per hectare (Equation 2)

Volume of $200m^2$= 40m x 5m x 0.30m

Weight of Soil (Mg) = bulk density x volume (Equation 3)

Carbon Density(Mg/ha^{-1})=weight of soilx%SOC (Equation 4)

V. RESULTS AND DISCUSSION

A. Computed Basal Area and Tree Volumes

Table 1 shows that benguet pine has the widest basal area per hectare of 280.85sq.m/ha. at plantation age of 10 years followed by white lauan with 269.05sq.m/ha at 25 years. In terms of tree volumes, it was found out that white lauan has the largest tree volumes of 997.56 cu.m / ha followed by benguet pine of 867.05 cu.m /ha.

TABLE I. COMPUTED BASAL AREA AND TREE VOLUMES OF THE FOUR INDIGENOUS TREE SPECIES IN COTABATO AND BUKIDNON PROVINCES.

Plantation	**No. of Trees**	**Age**	**DBH Class (cm)**	**MH (m)**	**TH (m)**	**Basal Area (sq.m/ha)**	**Vol. (cu.m/ha)**
White lauan*(Shorea contorta)*	19	25	11-34.7	28.14	41.13	269.0467	997.56
Almaciga(*Agathis philippinensis*)	13	20	5-25.5	14.77	18.54	140.9965	308.64
Dao(*Dracntomelon dao*)	9	14	8.5-25	20.95	22.67	108.8506	360.63
Benguet Pine*(Pinus kesiya)*	13	11	16.5-31	25.94	36.46	280.8506	867.05

B. Biomass Production and Carbon Storage of the Selected Indigenous Tree Species

Table 2 presents the biomass production of the selected indigenous tree species in Cotabato and Bukidnon. The computed root biomass of white Lauan is 203.35 Mt/ha, Almaciga (145.29Mt/ha, Dao (149.26Mt/ha) and Benguet Pine (276.54Mt/ha.)

In terms of above ground biomass, White lauan has 1,098.02Mt/ha, Almaciga (750.50Mt/ha), Dao (773.73Mt/ha), Benguet Pine (1554.92Mt/ha).

The above ground biomass of Almaciga is (750.50Mt/ha), White Lauan (1098.01Mt/ha), Dao (773.73Mt/ha), Benguet Pine (1554.92Mt/ha).The ground biomass of White Lauan is 0.29 Mt/ha), Almaciga (0.005 Mt/ha), Dao (0.01 Mt/ha), and Benguet Pine (0.01Mt/ha).

In terms of soil organic carbon, White lauan is (624.28 Mt/ha), Almaciga (600.05 Mt/ha), Dao (594.26Mt/ha), Benguet pine (558.19Mt/ha).The tree carbon storage of White lauan is (585.62Mt/ha), Almaciga (403.11Mt/ha), Dao (415.34Mt/ha), Benguet pine (824.16Mt/ha).

Benguet pine has the greatest carbon trapped of 824.16 Mt/ha with average carbon sequestration of 74.92Mt/ha/year which is 69% greater than white lauan, 73% greater than almaciga, and 60% greater than dao plantations.

TABLE II. BIOMASS PRODUCTION OF THE PLANTATIONS (RB-ROOT BIOMASS; ABG-ABOVE GROUND BIOMASS) AND CARBON STORAGE.

Plantation	**RB (Mt/ha)**	**AGB (Mt/ha)**	**Ground Biomass (Mt/ha)**	**SOC (Mt/ha)**	**Tree C Storage (Mt/ha)**	**Ave. C Sequest'n (Mt/ha/yr)**
White lauan*(Shorea contorta)*	203.35	1098.02	0.02925	624.28	585.6171	23.42
Almaciga(*Agathis philippinensis*)	145.29	750.50	0.00573	600.05	403.1075	20.15
Dao(*Dracntomelon dao*)	149.25	773.73	0.01002	594.26	415.3432	29.67
Benguet Pine*(Pinus kesiya)*	276.55	1554.92	0.01270	558.19	824.1595	74.92

C. Percent Biomass and Carbon Density of Various C Pools of Selected Indigenous Tree Species

The root biomass of the White Lauan is 15.62% of the total biomass. Its above ground biomass is 84.38%. The root carbon is 7.56%, Above ground carbon is 40.86% and its soil organic carbon is 51.59%.

The root biomass of Almaciga is 16.22%, the above ground biomass is 83.78%, its root biomass carbon is 7.56%. The above ground carbon is 33.67% and the soil carbon is 59.81%.

The root biomass of Dao is 16.17%, Above ground biomass is 83.83%,. The root biomass carbon is 6.65%. Its above ground carbon is 34.49% and the soil carbon is 58.86%.

The root biomass of Benguet pine is 15.09%, the above ground biomass is 84.90%. Its root biomass carbon is 9%. The above ground biomass carbon is 50.62% and its soil carbon is 40.385.

Roots often represent 10-40 percent of total biomass and it transfers large amounts of Carbon directly into the soil (Mac Dicken 1997). Estimating carbon from root biomass can be determined by using conservative estimates based on literature, and actually measuring of the root biomass through destructive sampling (Mac Dicken 1997). The computed root biomass of the different plantations in the study ranges from 15.09% to 16.22% which is in accordance with the findings of Mc Dicken 1997.

TABLE III. PERCENT BIOMASS CARBON DENSITY VALUES OF VARIOUS C POOLS OF THE DIFFERENT PLANTATIONS.

Plantation	**Age (years)**	**RB (%)**	**AGB (%)**	**RB carbon (%)**	**AGB carbon (%)**	**Soil Organic Carbon (%)**
White lauan(*Shorea contorta*)	25	15.62	84.38	7.56	40.85	51.59
Almaciga(*Agathis philippinensis*)	20	16.22	83.78	6.52	33.67	59.81
Dao(*Dracontomelon dao*)	14	16.17	83.83	6.65	34.49	58.86
Benguet Pine*(Pinus kesiya*)	11	15.09	84.90	9.00	50.62	40.38

D. Relationship of the Carbon Density of the Selected Indigenous Tree Species with Various C Pools of the Different Plantations

Figure 2 to Figure 10 shows the linear relationship of the carbon density of the indigenous tree species with C pools of each plantation.

All presented scatter plot reveals strong relationship of carbon density with C pools of each plantation. This implies that carbon content of the different indigenous tree species is dependent on the various carbon pools of each plantation.

VI. Conclusion

Based on the result of the study, the carbon trapped by the four selected indigenous hardwood tree species vary greatly. At plantation age of 11, benguet pine has able to trapped 824.16 Mt/ha carbon with average annual carbon sequestration of 74.92Mt/ha/yr., dao at 20 years was able to trapped 415.34Mt/ha carbon and average of 29.67Mt/ha/yr C sequestration, white lauan at 25 years has 585.62Mt/ha carbon storage and 23.42Mt/ha/yr C sequestration), and almaciga (403.11Mt/ha carbon storage and 20.15Mt/ha/yr C sequestration) at 20 years.

It was noted that among the carbon pools of all the plantation species, soil has the highest carbon storage content followed by the above ground biomass and the least was found on the ground biomass (Table 3).

Recommendation

The selected indigenous tree species have potentials in trapping and sequestering carbon for climate change mitigation. The estimation was done by field sampling and measurement. To validate the results, it is recommended to conduct similar study employing destructive sampling to obtain the exact carbon storage of each plantation species. A comparative study of indigenous tree species with exotic and fast growing tree species in trapping and sequestering carbon is also recommended.

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