ISSN 2348-1218 (print)
International Journal of Interdisciplinary Research and Innovations ISSN 2348-1226 (online)
Vol. 4, Issue 2, pp: (19-25), Month: April - June 2016, Available at: www.researchpublish.com

Above-Ground Carbon Stock Assessment of Mango-Based Agroforestry in Bulbul, Rizal, Kalinga, Philippines

Ernesto G. Guiabao

Faculty member, Rizal Campus, Kalinga State University, Bulbul, Rizal, Kaling, Philippines

Abstract: **The study was conducted in four sites located in Bagbag, Bulbul, Rizal, Kalinga. The study aimed to determine the above-ground biomass, carbon stock and soil fertility of the four mango plantations site.**

The methodologies used includes interview, measurement of trees at the diameter at breast height (dbh), collection of soil samples, gathering of corner points with the use of GPS and processing of data in Arc GIS. Above ground biomass was computed through the allometric equation developed by Brown, (1997).

Result showed that the site 2 had the highest above-ground biomass and carbon stock which is equal to 18.51 t/ha, and 8.33 t/ha respectively followed by site 4 (16.07 t/ha, 7.24 t/ha), site 3 (12.29 t/ha, 5.53 t/ha), and lowest at site 1 (7.32 t/ha, 3.24 t/ha).

In terms of soil chemical properties, the four sites revealed that pH, Nitrogen, and Phosphorus are moderately low while potassium was very high which has a mean of 705ppm.

Keywords: **Carbon Stocks, Biomass, Mangifera Indica, Soil Fertility.**

1. INTRODUCTION

Carbon sequestration is the process by which carbon dioxide (CO2) from the atmosphere is absorbed by trees, plants and crops through photosynthesis and stored as carbon in biomass such as tree trunks, branches, foliage, roots and soils (EPA, 2010). A variety of human activities lead to the emission of CO2 which are referred to sources of CO2 and the removal of CO2 refers to sinks of CO2. However, forests and soils have a large influence on atmospheric levels of CO2 as the forest vegetation serves as a major component of the global carbon cycle and it is estimated that the forest vegetation stores at least 350pg of carbon (Dixton *et al.*, 1994). It is also estimated that as much as 90% of the world's terrestrial carbon is stored in the forest (Houghton, 1996). Although the forest can store high levels of CO2, the estimated carbon storage by the forest is subject to either an increase or decrease due to factors such as conversion of forest lands to other land uses, harvesting of timber, mining etc. resulting in changes in carbon fluxes to the atmosphere. These human activities are also considered as factors that lead to loss of vegetation cover resulting in deforestation and forest degradation. Forest degradation and deforestation are said to result in 20 per cent of global green house gas emissions with carbon dioxide taking the greater part. In view of this, tropical deforestation has also been reported to be responsible for about 20 percent of the world's annual carbon dioxide emission (IPCC, 2000). Forest soils are also major sinks of CO2 because of their higher organic matter content. Soils found under forest vegetation are said to be richer in plant nutrients as a result of high rate of decomposition of biomass and high rate of supply of organic materials in the soil. Globally, soils are estimated to contain approximately 1,500 gigatons of organic carbon, more than the amount in vegetation and the atmosphere (Batjes, 1996 and Smith, 2008).

1.1 Plant study:

The scientific name of mango tree is *Mangifera indica* L. It belongs to Anacardiaceae family. The canopy of *Mangifera indica* is evergreen and fast growing tree. Mango is a common garden tree throughout the tropics. Most of the fruit trees belonging to this family that are commonly known as mango trees and belong to the species *Mangifera indica*. The wild

Mangifera species are generally edible but have lower quality fruits. The mango tree have adapted throughout the tropics and subtropics. Much of the spread and naturalization has come about in conjunction with the spread of human populations. Mango tree is an evergreen tree changeable in height from 5 to 40m in with a short straight bole reaching a diameter to 100cm.

The total tree biomass is composed of following components (Bally, 2006.)

1. Bark & Branches: The bark of mango tree is somewhat rough, fissured and dark brown to grey. Its twigs are rounded, stout, and glabrous with prominent leaf scars. Its shoots are reddish-green and smooth, turning light brown shoots.

2. Leaves: The leaves of mango tree are simple, alternate, petiolate and at 2-10 cm and distinctly thickened at the lower end and smell of turpentine when these are crushed. They are glabrous in appearance and shaped like front. They extend from 15-30 cm in length and 4-6 cm in width. They are reddish-brown when young and turn a shiny dark green with age.

3. Flowers: The flowers are in bunches, 5-7mm across and may be male or hermaphrodite. They consist of 5 green triangular sepals, 5 clawed with curved petals, Flowers appear in the period of December to May and fruits in April to August.

4. Fruits: The mango fruits are botanically considered to be edible drupes. They are initially with green peels and turn various shades of red, yellow and green colors after growth and when ripe. The fruits of commercially cultivated species are larger in size and more in weights. The pulp surrounds a stony hard coat that contains a seed in each fruits.

The mango fruit is an important source of sustenance for birds, bats, insects, and mammals. Although grown widely, mangos prefer dry season. Rain and high humidity during flowering stage and fruit development stage reduces fruit yields. Mango trees are usually between 3 and 10 m (10–33 ft.) tall but can reach up to 30 m (100 ft.) in some natural forest situations. The canopy is evergreen with a generally spreading habit. The heavy canopy of the mango is a good shelter and shade for both animals and humans. Mangos are well adapted to cultivation in various soils and have been grown commercially for centuries. Today, mangos are well recognized and eaten throughout the world. They are regarded as one of the most popular and esteemed tropical fruits.

***1.2 Distribution*:** The genus *Mangifera* originates in tropical Asia. The large numbers of species are found in Borneo, Java, Sumatra, and the Malay Peninsula. The most-cultivated *Mangifera* species, *M. indica* (mango), has its origins in India and Myanmar (Bally, 2006).

India ranks first among world's mango producing countries. It accounts for about 50% of the world's mango production. India's shared around 12 million tons as against world's production of 23 million tons as figured in 2002-03. An increasing trend has been observed in world mango production averaging 22 million metric tons per year.

Worldwide production is mostly concentrated in Asia, accounting for 75%. It is followed by South and Northern America with about 10% share. The other major mango producing countries include China, Thailand, Mexico, Pakistan, Philippines, Indonesia, Brazil, Nigeria and Egypt

1.3 Economic Importance: The fruits of mango are is incredibly popular with the ample due to their wide range of adaptability, high nutritive value, richness in variety, delicious taste and excellent flavor. Mango fruit is rich source of vitamin A and C. Good mango varieties contain 20% of total soluble sugars. The acid content of ripe desert fruit varies from 0.2 to 0.5 % and protein content is about 1 %. The wood is relatively soft and used as timber and dried twigs are used for religious purposes. The mango fruit kernel is most important part and contains about 8-10% good quality fat useful for saponification. Its starch is used in confectionery industries. Mango has medicinal uses too. The ripe fruit is high in calories with diuretic and laxative properties. It helps to increase digestive capacity (Bally, 2006).

Importance of the Study

This study attempts to assess the carbon stock of mango plantations in Bagbag, Rizal Kalinga. Data generated from it could provide valuable information to policy makers who may formulate policies that would enhance the well being of the mango plantation owners. This study provides researchers in the province the baseline information on carbon reserve of the mango plantations.

The importance of planting and managing mango plantations contributes to the additional sink for carbon. It is in this regard that quantification is necessary to determine the contribution of mango plantations as sink of carbon.

Objectives of the Study:

Generally, the study assessed the above-ground carbon stock of mango (*Mangifera indica*) in Barangay Bagbag, Bulbul, Rizal, Kalinga.

Specifically, the study aimed to:

1. Determine above-ground biomass and carbon stocks of Mango (*Mangifera indica*)plantations; and

2. Determine the soil fertility of the plantation sites;

Time and Place of the Study:

The study was conducted from December to March 2016 at Barangay Bagbag, Bulbul, Rizal, Kalinga.

Scope and Limitation of the Study:

The study focused on the assessment of carbon stock and soil fertility of mango plantation in Barangay, Bagbag, Rizal, Kalinga.

Below are the limitations of the study

Carbon stock assessment. Carbon stock was computed using the allometric equation used by Brown, (1997) instead of obtaining destructive samples.

The diameter limit use in assessing the biomass is 10 cm and above although some studies used 5 cm and above such as Sales (2005) and others. This is due to the facts that Brown (1997) is the author of the allometric equation used under this study and the same suggested the 10 cm diameter limit. Lasco and Sales (2003) actually suggested the same diameter limit.

2. METHODOLOGY

Site of the Study:

The study includes the four mango plantation sites in Barangay Bagbag, Bulbul, Rizal, Kalinga. Site 1, site 2, site 3, and site 4 has an area of 2.6 has., 4.8 has., 1.6 has and 1.4 has. respectively. The sites are located along the highway in the western part of the community.

Rapport Building:

Before the official conduct of the study, the researcher conducts courtesy calls to the owners and discusses the objectives of the research and obtains permission.

Field and Laboratory Methods:

Carbon Stock Assessment:

A 100% quantification of carbon stock found within above-ground biomass was conducted. Diameters having a dbh of 10 cm and above were recorded, and for those which do not reach the dbh were measured at the first big branch.

Above-ground biomass was computed using the following allometric equation (adopted from Brown, 1997).

$Y = \exp[-2.134 + 2.530 * \ln(D)]$

Where, Y=biomass per tree in Kg

D=dbh in centimeters

In=natural logarithmic

Carbon Stock= Biomass x 0.45

Mapping:

Corners of individual parcel of farms of the respondents were taken using GPS. This data was process through the ArcGIS 9.3. to determine the actual area of the site.

Inventory:

Trees with diameter of 10 cm and above were recorded as followed from Brown 1997. The data was encoded and processed through Microsoft Excel to facilitate computation.

Soil Chemical Properties:

Soil samples were collected from different part of the plantation area with dimensions of 25 cm x 25 cm and 30 cm depth. Representative samples were obtained for air drying. 8 samples were collected in the four plantation sites. These samples were placed in labeled plastic bags and transported to the soil laboratory of the Bureau of Soils- Department of Agriculture Tuguegarao City, Cagayan for the analysis of pH, nutrients: nitrogen, phosphorus and potassium.

Data Analyses:

Simple descriptive statistics was used such as frequency counts, percentage, ranking and means to analyze the data gathered.

3. RESULTS AND DISCUSSIONS

Diameter Class Distribution in the Study Sites:

Table 1 presents the diameter class distribution in the study sites to give better picture of the sites.

Table 1. The diameter class (cm) distribution of Mango stands in Rizal, Kalinga

Diameter Class (cm)	**Number of plants per site**				**Total**
	Site 1	**Site 2**	**Site 3**	**Site 4**	
10-20	114	77	153	73	**417**
21-30	15	82	3	32	**132**
31-40	3	35			**38**
41-above		4			**4**
TOTAL	**132**	**198**	**156**	**105**	**591**

The age of site 1, site 2, site 3, and site 4 is 8, 10, 9 and 6 years respectively. As shown in table 1, site 2 has the highest diameter which indicates that the mango planted is the oldest among the four sites.

Aboveground Biomass Estimation:

The above-ground biomass of *Mangifera indica* trees in Barangay Bagbag, Rizal, Kalinga was observed in site 2 to have the highest aboveground biomass which is equal to 18.51 t/ha, followed by site 4 (16.09 t/ha), site 3 (12.29 t/ha) and lowest at site 1 (7.2 t/ha). The diameter of the trees had an influence on the above-ground tree biomass obtained from the plantation. Perez and Kanninen (2003) revealed that the total above-ground biomass is influenced by the diameter and age class of a plantation. As the diameter of trees increases with age, the above-ground biomass also increases respectively resulting in increases of total above-ground biomass.

Table 2. Aboveground biomass and Carbon stock of the Four study sites

STUDY SITES	**AREA (has.)**	**AGE (YEAR)**	**Aboveground Biomass (tons)**	**Biomass (tons/has)**	**Total carbon(tons)**	**Carbon stock(t/ha)**
SITE 1	2.6	8	19.02	7.20	8.56	3.24
SITE 2	4.8	10	88.86	18.51	39.98	8.33
SITE 3	1.6	9	19.66	12.29	8.85	5.53
SITE 4	1.4	6	22.5	16.09	10.14	7.24
TOTAL	**10.56**		**150.04**	**54.19**	**67.53**	**24.34**

Aboveground Carbon Stock Estimation:

Biomass is used to provide an estimate of the carbon reservoirs in ecosystems based on the fact that about half of it is Carbon. 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.

ISSN 2348-1218 (print)
International Journal of Interdisciplinary Research and Innovations ISSN 2348-1226 (online)
Vol. 4, Issue 2, pp: (19-25), Month: April - June 2016, Available at: www.researchpublish.com

Parallel to the rise in concern about climate change, there is also considerable interest in the role and importance of mango plantations for carbon sequestration and storage. Plantations had been providing various and enormous environmental services to the surroundings or adjacent communities. The huge amount of carbon stock is a manifestation that considerable volume of such element has been stored and kept from intensifying the global warming phenomenon. Such contribution must also be responsible for the pleasant microclimatic condition of the area giving the local people a human-friendly and habitable place to stay.

The sequestered aboveground carbon of *Mangifera indica* trees in the four study sites showed (table 2) that site 2 has the highest carbon content (8.33 t/ha), followed by site 4 (7.24 t/ha), site 3 (5.53 t/ha) and site 1 (3.24 t/ha).

The above-ground carbon stock of the study is comparable to the findings of (Jana, 2009) in selected forest lands; he estimated for *Shorea robusta*, *Albizzia lebbek*, *Tectona grandis* and *Artocarpus integrifolia* were 5.22, 6.26, 7.97 and 7.28 tC/ha respectively.

Soil Chemical Characteristics of the Four Study sites:

Table 1 showed the chemical soil characteristics of the study area. Brady (1978) noted that while soil analysis indicates the capacity of a soil to supply nutrients to the plants, it does not adequately and in some cases does not at all characterize the mobility of nutrients in the soil.

STUDY SITES	pH	Nitrogen (ppm)	Phosphorus (ppm)	Potassium (ppm)
SITE 1	5.25	1.85	3	565
SITE 2	5.25	2.3	2	805
SITE 3	5.25	1.95	1.5	450
SITE 4	5.45	1.85	15.5	1000
Mean	**5.3**	**1.98**	**5.5**	**705**

Soil pH:

The most universal effect of pH on plant growth is nutritional. The soil pH influences the rate of plant nutrient release by weathering, the solubility of all materials in the soil, and the amount of nutrient ions stored on the cation exchange sites. Usually the optimum pH is somewhere between 6.0 and 7.5 because all plant nutrients are reasonably available in that range. Based from the soil analysis conducted, it showed that the four sites have moderately acidic soil. Comparison among the study sites revealed that site 1, Site 2, and site 3 have the same pH value of 5.25 and 5.45 for site 4. Based on FAO (1973) as cited by Gascon (1998), the four sites have moderately acidic soils.

Total Nitrogen:

Nitrogen is a primary nutrient needed by the plants. Its presence in higher amount indicated soil fertility (Thompson & Troeh, 1978, cited by Gascon, 1998; cited by Rodolfo, 2012). The study revealed that the site 2 had higher nitrogen in terms of nutrients to be 2.3 followed by site 3 (1.95) and the same Nitrogen content in site 1 and site 4. The sites have nitrogen level described as moderate (FAO Staff, 1973, cited by Gascon, 1998).

Available Phosphorus:

In many natural ecosystems, phosphorus is the more likely limiting element (Odum, 1971 as cited by Navasero, 1993; and Gascon, 1998).

The site 4 had higher level of Phosphorus with 15.5ppm followed by site 1 (3ppm), site 2 (2ppm), and site 3 (1.5ppm) Based on Phosyn Chemicals Limited (1987, cited by Palijon, 1998), the guideline level for phosphorus is 50 ppm. The study revealed that the study sites were low in phosphorus which has a mean of 5.5ppm.

Available Potassium:

Potassium (K) availability in the soil depends largely on the density of standing biomass (Raves 1978, Mohr & Van Baren, 1954 cited by Navasero, 1993; cited by Gascon, 1998).

Result of the study revealed that the site 4 had higher soil potassium content (1000ppm), followed by site 2 (805ppm), site 1 (565ppm), and site 3 (450ppm).

Based on Phosyn Chemicals Limited (1987, as cited by Palijon, 1998), the guideline level for potassium is 200 ppm. It was observed that the four sites exceed the guideline level for potassium which indicates that the sites have very high potassium content.

Comparing the analysis of soil nutrients to a study conducted by Imoro *et al.* (2012) the levels of nitrogen and organic carbon added by the mango plantation (0.05) and (0.63) were less than levels added by the teak plantation (0.35) and (2.4) and *Albizia* plantation (2.3) and (1.9) respectively. However, the levels of phosphorous added by the mango plantation (5.29) were higher than the levels of phosphorous added by the *Albizia* plantation (4.8) but less than levels added by the added by the teak plantation (5.7) respectively. This might be due to the difference in the ages of these plantations. A study conducted by Jaiyeoba (1995) showed that soil conditions were slightly better under *Mangifera* than under *Eucalyptus* plantations but the differences were mostly non-significant.

4. CONCLUSION

Based on these results, the following conclusions were drawn:

1. Site 2 has the highest aboveground biomass which is equal to 18.51 t/ha, followed by site 4 (16.09 t/ha), site 3 (12.29 t/ha) and lowest at site 1 (7.2 t/ha). and carbon stock followed by site 4, site 3, and site 1.
2. The Aboveground carbon sequestered by site 2 was (8.33 t/ha), followed by site 4 (7.24 t/ha), site 3 (5.53 t/ha) and site 1 (3.24 t/ha).
3. The soil chemical properties of the four sites revealed that pH, Nitrogen, and Phosphorus are moderately low while potassium was very high which has a mean of 705ppm.

5. RECOMMENDATIONS

The study recommends that more communities should be encouraged to plant and use mango as a component of agroforestry. Information dissemination on the contribution of mango plantations to carbon sequestration should also be done.

REFERENCES

[1] BROWN S. 1997. Estimating Biomass and Biomass of Tropical Forest: A Primer. FAO Forestry Paper No. 134 Rome: Food and Agriculture Organization. P55.

[2] EPA (2010).Environmental co-benefits of sequestration practices. Internet file http;//www. epa.gov/sequestration/ fag.html April, 2012.

[3] Dixton, R. K., Brown S. Houghton, R. A., Solomon, A.M., Trexler, M. C and Wisniewski J.(1994). Carbon pools and fluxes of global forest ecosystem. Science 263,185-190.

[4] Houghton, R.A. (1996). Terrestrial sources and sinks of carbon inferred from terrestrial data. Tellus B 48, 420-432pp

[5] IPCC (2000).Special Reports on Climate Change Land Use, Land-Use Change and Forestry.Cambridge: Cambridge University.

[6] Batjes, N. H. (1996). Total carbon and nitrogen in the soils of the world. European Journal of Soil Science 47 (2), 151-163.

[7] Bally Ian S.E., 2006. *Mangifera indica,* Species specific for pacific island Agroforestry, V.3, www.traditionaltree. org.

[8] LASCO, R.D. and R.F. SALES. 2003. Estimating carbon storage and sequestration of Philippine forest ecosystems.

[9] *Smallholder: Forestry Research Paper Series*. Los Banos: College of Forestry and Natural Resources, Leyte State University, Baybay Leyte.

[10] Perez, C.L.D. and Kanninen, M. (2003).Above ground biomass of *Tectona grandis* plantation in Costa Rico. Journal of Forest Science 15(1), 199-213.

[11] Jana, B. K., Biswas, S., Majumder, M., Roy, P. K., Mazumdar, A., 2009. Comparative Assessment of Carbon equestration

[12] Rate and Biomass Carbon Potential of Young *Shorea robusta and Albizzia lebbek, International Journal of Hydro-Climatic Engineering Assoc. Water and Enviro-Modeling,* 1-15.

[13] GASCON, C. S. 1998. Sustainability Indicators of the Hanunuo Mangyan Agroforestry Systems, Sitio Dangkalan, Bulalacao, Oriental Mindoro. Ph.D. Dissertation. UPLB..

[14] PALIJON, A.M. 1998. An Analysis of Green Space Management Strategies in Metro Manila. Ph.D. Dissertation. UPLB.

[15] Imoro, A. Z., Tom-Dery, D. and Kwadjo, A. K. (2012). Assessment of soil quality improvement under teak and Albezia Plantations. Journal of Soil Science and Environmental Science 3 (4),91 - 96.