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Above Ground Carbon Stock Through Palm Tree in the Homegarden of Sylhet City in Bangladesh

Anna Dey, Mahmuda Islam* and Kaji Mohammed Masum
Department of Forestry and Environmental Science, Shahjalal University of Science and Technology, Sylhet-3114, Bangladesh

Abstract

An explanatory survey was conducted to assess the contribution of palm species in carbon sequestration in the homegarden of the Sylhet Metropolitan City Corporation of Bangladesh. Assessment was done by means of two stage random sampling. A total of 10 housing area were selected randomly for the study and 4 common palm tree species were found abundantly. From the observations abundance of palm trees [*Areca catechu* (175/housing area), *Cocos nucifera* (145/housing area), *Borassus flabellifer* (124/housing area) and *Phoenix sylvestris* (27/housing area)] were found higher in all homesteads in comparison with other species. Study revealed that total organic carbon (MTOC mt/ha) was highest in *Cocos nucifera* (12.48 mt/ha), followed by *Areca catechu* (4.20 mt/ha), *Borassus flabellifer* (3.02 mt/ha) and *Phoenix sylvestris* (0.59 mt/ha). Total amount of organic carbon stored by palm trees in homestead areas was found 20.28 metric ton/ hector in the study area. Study revealed that palm trees of homestead forest accumulate a good amount of biomass and is a good sinker of organic carbon from the atmosphere. Proper management of palm trees will help to improve the local, national and international community through carbon sequestration.

Key Words: carbon, homegarden, plamtree, sylhet

Introduction

Global warming and climate change are growing environmental concerns that are resulting from the accumulation of greenhouse gases such as carbon dioxide (CO_2) in our atmosphere. There is strong evidence that human activities have affected the world's climate (IPCC 2001a). Deforestation and burning of forests releases CO_2 to the atmosphere. The CO_2 concentration in atmosphere increased from 280 ppm at the beginning of the industrial revolution to 368 ppm by the year 2000 and is projected to increase to 540 ppm by 2100 (Houghton et al. 2001). Indeed, land-use change and forestry (LUCF) is responsible for about 25% of all greenhouse emissions.

As international agreements over greenhouse gas emissions and global warming are negotiated, there is growing interest in the possibility of reducing the increase in the amount of CO_2 in the atmosphere through forest-based carbon sequestration project. Forest ecosystems can be sources and sinks of carbon (Watson et al. 2000). It plays an important role in sequestration of carbon globally (Rawat et al. 2003). Forests sequester and store more carbon than any other terrestrial ecosystem and are an important natural 'brake' on climate change.

The Kyoto Protocol, under the UNFCCC, is an agreement designed to limit the release of GHGs into the atmosphere, in order to prevent catastrophic climate change. The Kyoto Protocol created financial incentives for new terres-

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Corresponding author: Mahmuda Islam

Department of Forestry and Environmental Science, Shahjalal University of Science and Technology, Sylhet-3114, Bangladesh
Tel: 8801712172658, Fax: 880-821-716312, E-mail: mahmudafor@yahoo.com

trial carbon sequestration (although with extremely limited impact to date). The Protocol also provides for flexible mechanisms to meet carbon reduction obligations. The most relevant to developing countries is the Clean Development Mechanism (CDM). Essentially, the CDM allows Annex 1 (developed) countries to meet their carbon reduction quota via activities in developing countries (non-Annex 1 countries). Projects implemented under the Clean Development Mechanism (CDM) of the Kyoto Protocol will offer opportunities for investors seeking "Certified Emissions Reductions" (CERs) to invest in developing countries for the dual objective of reducing greenhouse gas emissions and contributing to sustainable development. In the global trends of forestry business, carbon sequestration has been emerged as a potential profitable business, which is oriented to socio-economic development and environmental amelioration. Forests play an important role in the global carbon cycle because they store a large amount of carbon in vegetation biomass and soil.

A typical homestead forest, nevertheless, is an integral part of the farmer's farming system and an adjunct to the house, where selected trees, shrubs and herbs are grown for edible products and cash income, as well as for a variety of outputs that have both production and service values including aesthetic and ecological benefits. Although agroforestry literature lists homegardens as an agroforestry practice (Nair 2001), it could be more appropriate to say that homegardening is a generic concept - much like agroforestry itself. Both involve diverse life forms and managerial regimes, which exist in harmony with one another on the same land management unit and/or on the landscape level. Due to their high biomass, these systems simultaneously offer potential for carbon storage. While small size limits the amount of carbon stored by individual smallholder agroforestry systems, on a per area basis these systems can storage as much carbon as some secondary forests.

The homegardens are also significant sources of minerals and nutrients (Asfaw and Woldu 1997). In addition, the diverse products available year-round in the homegardens contribute to food security especially during 'lean' seasons (Karyono 1990). Another key dimension of homegardening is the equitable distribution of the produce within the community. While a large proportion of the production is consumed domestically many products such as fruits, vegetables and medicinal/ornamental plants are also generously shared within the local communities (Soemarwoto 1987). Traditional homegardens have been shown to be ecologically sustainable (Jose and Shanmugaratnam 1993). Their benefits include maintenance of soil fertility and soil structure and maintaining nutrient cycling (Schroth et al. 2001).

Palm trees are one of the major plantation trees for their fruits and sap collection of Bangladesh. Such as The coconut palm is one of the most important homestead and plantation crops of Bangladesh with multipurpose uses. It is regarded as an important commercial crop of the tropical world. Due to multifaceted uses, coconut has been eulogized as "Kalpavriksha" and is commonly referred to as "tree of life". The date palm not only provided a concentrated energy food, which could be easily stored and carried along on long journeys across the deserts. The date palm also yielded a variety of products for use in agricultural production and for domestic utensils, and practically all parts of the palm had a useful purpose. The Betel nut is a product of great cultural and symbolic significance. It is chewed and harvested by millions of people from different country. Sap from date palm has been used from time immemorial to produce traditional sweeteners, a mainstay of Bengali cuisine. Because of the extensive use of its sap in making sugar, it is of considerable importance for household economy in Bangladesh. The palm tree has always played an important role in our lives; one of the most well known plant families in existence. So many people choose to include palm trees in their own home and business landscaping (Pasaha 1996). The study was carried out in Sylhet Metropolitan City Corporation. I purposively select this area (as Sylhet Metropolitan City Corporation is residential area dominated city of Bangladesh) to estimate above ground biomasses accumulated by the palm trees and carbon sequestration by these trees from the atmosphere.

Terrestrially, carbon is stored in vegetation and in the soil. There are four components of carbon storage in a forest ecosystem. These are trees, plants growing on the forest floor (under-storey material), detritus such as leaf litter and other decaying matter on the forest floor, and forest soils. Plants store carbon for as long as they live, in terms of live biomass. Once they die, the biomass becomes a part of the food chain and eventually enters the soil as soil carbon.

The area covered by forest in Bangladesh is 17.08% of the total land area. 60% of the total forest area is controlled by the Forest Department, 29% is under the Unclassified State Forest and the remaining 11% is under homestead forest (FAO 2003).

Homegarden systems form a common land use practice. While most agroforestry systems have great potential for carbon sequestration, homegardens are unique in this respect. They not only sequester carbon in biomass and soil, but also reduce fossil-fuel burning by promoting woodfuel production, and conserve agro- biodiversity (Kumar and Nair 2004). In addition, they help in the conservation of carbon stocks in existing natural forests by alleviating the pressure on these areas (Kumar 2006). Moreover, there is no complete removal of biomass from the homegardens, signifying the permanence of this system. The homegarden area of Bangladesh is rich. Little information exists about these systems regarding carbon sequestration, but they are believed to offer significantly more carbon benefits than other types of land uses (e.g., agriculture, grasslands). The use of palm tree has been a traditional feature of rural and urban life in Bangladesh. Palms provide a multitude of useful products ranging from food, to materials for construction, tools and handicrafts. Palm trees contribute 26% of total annual income of the households (Rana et al. 2010). It is important to know the role of palm trees in biomass accumulation and carbon sequestration which has great nutrious and economic value. The present study will help the policy maker in understanding the total significance of palm tree including their sequestration ability so as to encourage its production through creating option in urban planning. The main objectives of the study are:

1. To asses the existing stands of common palm tree.
2. To estimate the amount of above ground biomass of palm trees in urban homegarden
3. To estimate the amount of organic carbon stored in the palm trees of urban homegarden.

Materials and Methods

Study area

The study was conducted in the residential area of Sylhet Metropolitan City Corporation. Sylhet is a major city in north-eastern Bangladesh. It is the main city of Sylhet Division and Sylhet District, and was granted metropolitan city status in March 2009. Sylhet is located on the banks of the Surma Valley. Area - Total 26.50 km^2 (10.2 sq mi). It is located between 24°43' and 25°05' north latitudes and between 91°40' and 92°01' east longitudes. Annual average highest temperature is 23°C and average lowest temperature is 7°C. Sylhet city is divided into wards; it has up to 27 wards and together with 210 mahallahs (areas) (Fig. 1).

Methods

Selection of the study area

The study was conducted in Sylhet Metropolitan City Corporation. Two stage stratified random sampling was carried out to select the study area. At first, residential area and commercial area were separated. As residential area was purely comprises of homegarden it was selected purposively. The residential area in Sylhet Metropoliton City Corporation comprises of 152 distinct housing areas. Out of these 6.5% housing areas, (i.e., 10 housing areas) were selected randomly. A 5-10% sampling intensity is generally adopted in forest resource assessments (Kumar 2011).

The selected ten housing areas of Sylhet Metropolitan City Corporation are given in Table 1. Size of each housing area was collected from specific housing area management committee.

Selection of sample plot

Each house was surveyed of selected ten areas. Each household was considered as a sample plot.

Data collection

I have conducted my study from January-2011to December -2011. For collecting data from the field, I conducted direct field visit, observation, measurement and interview.

Instrument used in field

Instrument used in my study was Haga altimeter for height measurement.

Biomass estimation in trees

From each homegarden height of each tree were measured to estimate the biomass and organic carbon content.

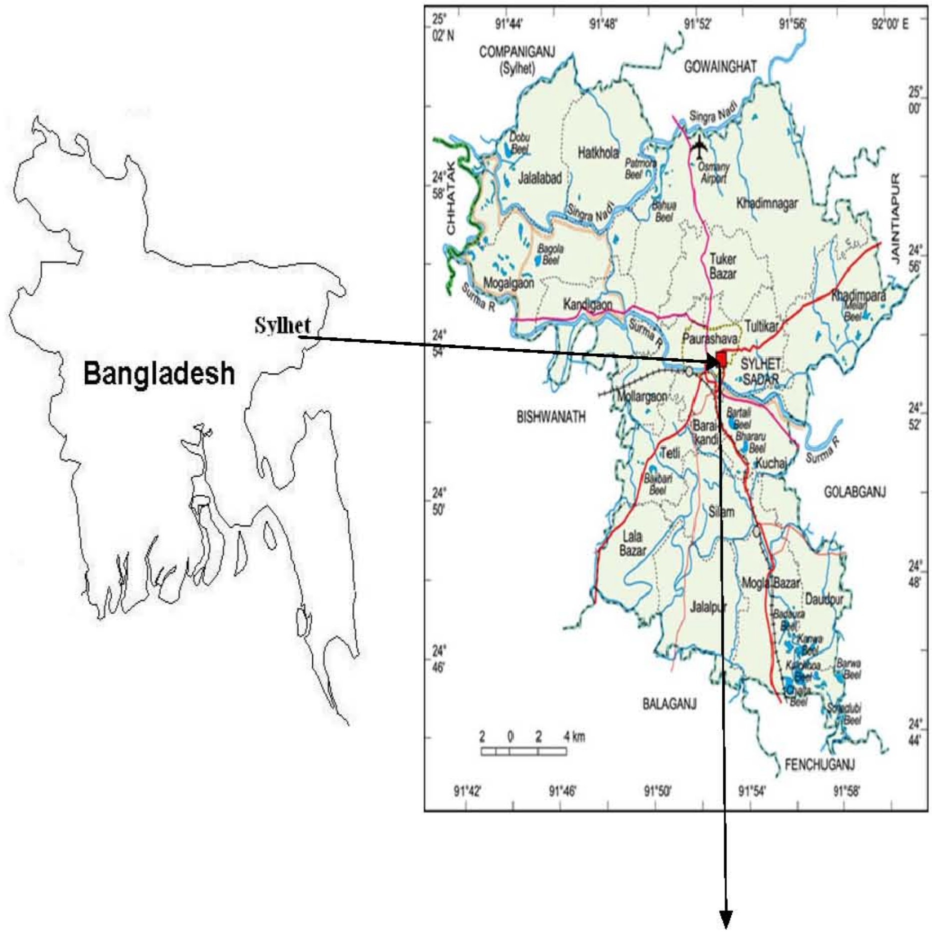

Fig. 1. Map of Bangladesh and Sylhet.

Above ground biomass estimation

The following models were used to calculate above ground biomass for coconut and other palm tree separately.

- Coconut palms: Y=5.5209x+89.355 (where Y=dry weight, kg; x=tree age years; Kumar and Russell 2011).
- All other palm trees (areca palm or Areca catechu L., palmyra palm or Borassus flabellifer L., etc.): Y=4.5+7.7H (where Y = biomass, kg and H= stem height (m); Brown 1997).

Organic carbon estimation of trees

The organic carbon of the trees are measured from the biomass of the trees which is multiplies by the carbon factor. That means-

The organic carbon of the trees=Total dry biomass of the trees X Carbon factor.

Carbon factor used for the terrestrial tree species is 0.5 (Carswell et al. 2009)

After the field study, data were complied and then analyzed statistically with the aid of calculator and some computer package program viz- MS Word, MS excel, percentage of different parameters was found out to generate information. Processed data were presented in the form of table, graph and picture.

Results

Composition of Palm trees in the study area

Greater biodiversity of homegardens ensure longer term stability of carbon storage in fluctuating environments (Henry et al. 2009), apart from augmenting biomass production potential (Kumar 2006). Homegardens of my study area were rich in Palme tree. In my study area I have found the following 4 species of palm tree. In the study area

Table 1. Selected ten housing areas of Sylhet Metropolitan City Corporation for the study

Serial number	Name of housing area	Ward number	Number of homegarden	Area (hactor)
1.	Munshipara	3	122	1.96
2.	Khastobir	5	102	1.61
3.	Jalalabad	7	91	1.51
4.	Ghasitula	10	95	1.57
5.	Kuarpar	12	195	3.45
6.	Jamtola	14	60	0.96
7.	Jherjheri Para	18	120	1.94
8.	Luhar Para	18	85	1.38
9.	Sonar Para	19	80	1.28
10.	Uposhahor H Block	22	90	1.52
Total			1,040	17.20

Table 2. Plant per hector and average height of palm trees in the area

Botanical name	Plant/hector	Average height (m)
Cocos nucifera	85	9.75
Areca catechu	102	10.12
Phoenix sylvestris	16	8.93
Borassus flabellifer	72	10.30

the most frequent species was Areca catechu. Average 175 individuals of Areca catechu were found in each housing area. Second most frequent species was Cocos nucifera (145). Phoenix sylvestris (27) and Borassus flabellifer (124) were found in few numbers.

General information about the palm species

In the study areas average height was highest for Areca catechu, followed by, Borassus flabellifer, Cocos nucifera and Phoenix sylvestris. Plant per hector and average height of the trees are shown in the Table 2.

Height of palm trees

In my study area the average tall tree was *Borassus flabellifer* (10.30 m), followed by *Areca catechu* (10.12), *Cocos nucifera* (9.15 m) and Phoenix sylvestris (8.93 m). Original height Cocos nucifera (30 m), Areca catechu (20 m), Pheonix sylvestris (10 m) and Borassus flabellifer (30 m) (Pasaha 1996).

Biomass stock in palm trees

The highest amount of biomass was found in *Cocos nucifera* (total 293.63 kg/tree), then *Borassus flabellifer* (83.81 kg/tree), *Areca catechu* (82.42 kg/tree) and the lowest amount of biomass was found in the *Phoenix sylvestris* (73.26 kg/tree) (Fig. 2).

Organic carbon stock in palm trees

The result show that above ground organic carbon (kg/tree), mean total organic carbon (kg/tree) was highest in *Cocos nucifera* (293.63 kg; and 146.81 kg respectively) followed by *Borassus flabellifer* (83.81 kg and 41.90 kg) and Areca catechu (82.42 kg and 41.21 kg). The lowest mean above ground organic carbon (73.26 kg/tree), mean total organic carbon (36.63 kg/tree) was found in *Phoenix sylvestris* (respectively). Also total organic carbon (MTC mt/ha) was highest in *Cocos nucifera* (12.48 mt/ha) followed by *Areca catechu* (4.20 mt/ha) and *Borassus flabellifer* (3.20 mt/ha). The lowest amount of organic carbon was found in *Phoenix sylvestris* (0.59 mt/ha). The total amount of organic carbon stored by palm trees in homestead areas was 20.29 metric ton per hector in my study areas. Above ground biomass and Mean total carbon content/trees are given in the Table 3.

Comparison between palm trees and fruits trees in carbon sequestration

A comparison of palm tree with fruit tree showed that palm tree in the urban Sylhet contains more biomass

(135.78 kg/tree) and organic carbon (5.06 mt/ha) than fruit trees (dicot) (100.55 kg/tree and 2.19 mt/ha respectively) (Barkat 2010). Comparisons were given below in Table 4.

Discussion

Homestead forest is considered as the most alternative way for sustaining the natural resources (Alam and Mohiuddin 1992). Palm trees were found dominating over all other dicots in the study area from observations. This was mainly because of the high demand of palm tree product (fruit, juice, etc.) both in domestic use and in market. Moreover these trees carry ornamental value of the housing area and require less space for its sound development without any conflict with the neighbors. The study reveals that number of *Areca catechu* (102 p/h) were found more than all other palm trees. It might because of the preference of the households as well as for its least space requirement than other palm tree. In the study, the average height of all palm tree (*Cocos nucifera*- 9.75 m, *Areca catechu*- 10.12 m, *Pheonix sylvestris*- 8.93 m and *Borassus flabellifer*- 10.30 m) were found half of their original height (*Cocos nucifera- 30 m, Areca catechu- 20 m, Pheonix sylvestris, 10 m and Borassus flabellifer, 30 m*) (Pasaha 1996). Lack of mineral nutrients in soil and less availability of enough sunlight at the growing stage of palm trees may be the major cause of their less growth.

The tree components of agroforestry system can be significant sinks of atmospheric carbon due to their fast growth and high productivity (IPCC 2000). This study explored the similar results that Palme trees of homestead forest sequester a substantial amount of carbon. Study revealed that the biomass (kg/tree) and total organic carbon (MOTC mt/ha) was highest in *Cocos nucifera* 293.63 kg/tree and 12.48 mt/ha respectively. It might because of its higher diameter and higher average age. Moreover *Cocos nucifera* was the second highest among all other palm tree in total number (Table 2). On the other hand biomass and total organic carbon of *Areca catechu* was 82.42 kg/tree and 4.20 mt/ha respectively. Though the *Areca catechu* was the highest in amount but it sequester less carbon than *Cocos nucifera* which might because of its smaller diameter growth. *Phoenix sylvestris* accumulate lower amount of biomass

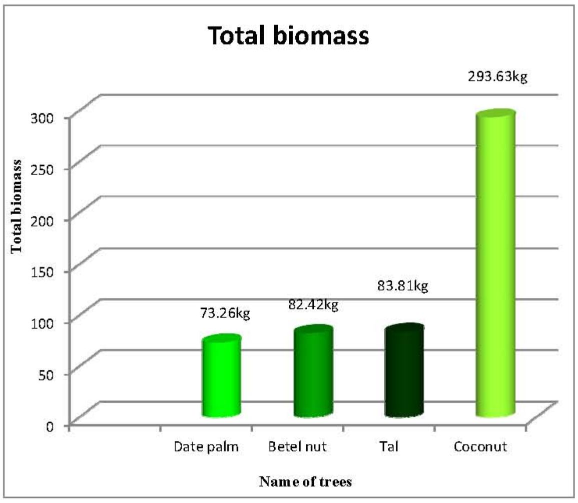

Fig. 2. Mean total biomass content per trees of palm species in the study areas.

Table 4. Comparative study between palm tree and fruit tree

Parameter	Palm tree (Tal, Coconut, Date palm, Betel nut)	Fruit tree (Kathal, Amm, Jam, Peyara) (Barkat, 2010)
Average Biomass stock (kg/tree)	135.78	100.55
Average Mean Total Organic Carbon (mt/ha)	5.06	2.19

Table 3. Biomass and organic carbon stock in palm tree

Scientific name	AGB (kg/tree)	CF	MTOC (Kg/tree)	P/h	MTOC (kg/ha)	MTOC (mt/ha)
Areca catechu	82.42	0.5	41.21	102	4,203.624	4.20
Borassus flabellifer	83.81	0.5	41.90	72	3,017.16	3.02
Cocos nucifera	293.63	0.5	146.81	85	12,479.2	12.48
Phoenix sylvestris	73.26	0.5	36.63	16	586.08	0.59

AGB, Above ground biomass; CF, Carbon Factor; MTOC, Mean total Organic carbon; p/h, plant per hector.

(73.26 kg/tree) and total organic carbon (0.59 mt/ha). It might because of its shortness and less preference than other three. From the result the biomass of *Borassus flabellifer*, *Areca catechu* and *Phoenix sylvestris* were near which may because of their similar height. The total amount of organic carbon stored by Palme trees in homestead areas was 20.28 metric ton per hector.

A comparison with fruit tree (Barkat 2010) showed that palm tree (Coconut, Betel nut, Tal, Date palm) accumulates more biomass and organic carbon (135.78 kg/tree and 5.06 mt/ha respectively) than common fruit tree (kathal, Amm, Peyara, jam) (100.55 kg/tree and 1.79 mt/ha respectively). It may be for the high abundance of palm tree in all homesteads in comparison with the other dicot fruit species. More over experience showed that palm tree can withstand better in adverse condition than the dicot.

At last it can be said that Palm trees in homestead forest can play a great role in biomass accumulation, carbon sequestration and climate change mitigation if we can increase its no. per housing are. Fellow portion of homestead can be use to accumulate a higher amount of biomass and organic carbon through the Palm trees in these housing areas.

Conclusion

Homegardens have a potential role in conservation as well as climate change mitigation one step forward.The composition of homestead species usually represents the householder need and knowledge. The owner concentrates on Palm species because of their subsistence and cash need. Multipurpose nature of palm tree is a major determining factor in this case. The overall study showed the predominance of palm trees in nearly all homegardens throughout the study area that ensure significant carbon sequestration. In a broader context, these results have implications on the role of traditional small holder tree-based production systems in greenhouse mitigation through palm tree. However, further research studies are required to predict and quantify the magnitude of the contribution of palm farming practices in the carbon sequestration mechanism.

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