Case Study

Carbon Sequestration in the Trees of Community Forest: A Case Study of Hasantar Community Forest, Kathmandu, Nepal

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Abstract

Carbon sequestration is one of the main ecosystem services in today's condition. Estimation of above ground tree biomass and carbon stock is important as it gives ecological and economic benefits to the local people. This study was conducted in the Hasantar Community Forest (HCF) of Nagarjun Municipality, Kathmandu. Concentric circular plots of 12.62m radius were established in five different blocks of HCF for the study of tree species. The main objective of this study was to find out the Important Value Index (IVI), Above Ground Tree Biomass (AGTB) and carbon stocks tree species of HCF. This forest comprises the tree species of families like fagacaeae, moraceae, myrtaceae, fabaceae etc in dominant numbers. *Schima wallichii* was found ecologically most significant tree species as it possess highest IVI value. The carbon stock of this plant was found as 206.865 t/ha which comprises 27 % of total carbon in HCF. The total above ground tree carbon stock of HCF (55.4 ha.) was found 144.795 t/ha.

Keywords: IVI; Carbon sequestration; ecosystem services; AGTB; carbon stock

Introduction

Community forestry is a participatory forest management system in Nepal that was started in the late 1970s. Glimour and Fisher (1991) defined community forestry as the control, protection and management of forest resources by rural communities for whom trees and forests are an integral part of their farming system. According to Forest Act 1993, community forest is a part or parts of National forest area handed over to a user groups for its development, conservation and utilization for collective benefit of the community. It is an institutional innovation of empowering local communities in managing forest resources for their benefit in co-ordination with government. According to the official website of MOFSC/ DoF/ GoN 2018, 18th February, about 1.45 million households or 35 percent of the population of Nepal is involved in community forestry management program. Hasantar community forest is located in ward no. 7 of Nagarjun municipality, Kathmandu. It was established in 2051 according to the Forest Act 2049. It lies about 3.5 Km north from Kalanki, Kathmandu. It covers 55.4 hectors land area.

Carbon sequestration refers to efforts to capture excess carbon dioxide from the atmosphere, condense it and store it in some benign way (Kirschbaum, 2003). Carbon sequestration is the removal of the CO_2 from the atmosphere

by storing it in the biosphere. Carbon is one of the essential elements of life and green plants have unique ability to assimilate it in the form of carbon dioxide as raw material for food preparation (Jain, 1983). Thus forest plays a key role in climate change, both sinks and sources of CO_2 (Shrestha *et al.,* 2016a). A forest is natural sinks for CO_2 and plays a significant role in sequestrating the atmospheric carbon into biomass and soil. It helps to reduce the concentration of greenhouse gases in atmosphere. The natural sinks of carbon include forest and soil (IPCC, 2000). Compared to other terrestrial ecosystem forests store the most carbon (Pan *et al*., 2011). The potential for carbon sequestration is quite high for mitigating the effects of global warming. It is known that the amount of carbon in the soils of terrestrial ecosystem is approximately three times that of atmosphere. The amount of carbon is also 700 times more than the estimated annual increase of carbon dioxide in the atmosphere. The terrestrial ecosystem are a huge natural biological scrubber for the CO_2 from the various sources. Carbon sequestration in terrestrial ecosystem can occur in living aboveground biomass. For effective carbon sequestration, the increased photosynthetic carbon fixation must occur in long lived pools. Trees take up CO_2 during photosynthesis plants can store carbon in above ground and below ground parts for longer period of time. It is estimated that 10 to 15 % of the excess carbon dioxide in the atmosphere can be removed by creating large tree plantation (Singh *et al.,* 2006). There is considerable variation in the above-ground carbon stock and rate of carbon sequestration according to forest types and its geographical location. Forests representing the Terai region of Nepal had high above-ground carbon stock per hectare compared to hilly region. However, carbon sequestration rate of forest types depended on growing nature of the forest stands. Tropical riverine, Pine and *Alnus nepalensis* forests are important for carbon sequestration in tree biomass in Nepal, as seen from the comparatively higher carbon accumulation rates (Baral *et al.,* 2009).

Materials and Method

This Hasantar Community Forest (HCF) is divided into five blocks for the easy management and protection of forest. According to Hasantar Community Forest User Group (HCFUG), this forest is in pole stage where maximum plants have diameter 10cm to 29.9 cm. It is north-west facing natural forest where Katush, Gurans, Chilaune, Utish, Pinus, Setikath, Kafal etc are dominant tree species. The primary data was collected from field visit and forest survey. Diameter at breast height (DBH), height of the tree, number of tree species, and number of sapling were recorded in the field. For the measurement of the height of tree Clinometer was used. Longitude and latitude, altitude, slope of the land were also recorded by using GPS, Altimeter and Compass during the field visit. The forest is subtropical type. The dominant tree species are *Schima wallichiana, Alnus nepalensis, Pyrus pashia, Prunus*

cerasoides, Myrica esculantum, Alnus nepalensis, Rhododendron arboreum etc. The five number of concentric circular sample plots of size 500m^2 and radius 12.62 m were established for the estimation of carbon stock. The primary data collected in the field was used in the calculation of the various vegetation parameters viz. relative density, relative frequency and relative basal area by using the formulas. The ecological value of a tree species of the community forest was calculated by adding Relative Frequency, Relative Density and Relative Basal Area.

Above ground tree biomass (AGTB) of the forest was calculated by the allometric equation developed by Chave *et al*. (2005) recommended by Ministry of Forest and Soil Conservation, Nepal.

AGTB= $0.0509\rho D^2 H$

Where,

AGTB= Above ground tree biomass (Kg)

ρ= Wood specific gravity (g/cm^3)

D=Tree diameter at breast height (cm)

H=height of tree (m)

The AGTB of all trees of the sample plot was summed up and it was divided by the area of sample plots (500m^2) which determined biomass stock density in Kg/m^2. This value of biomass stock density converted to t/ha by multiplying it by 10. The biomass stock of a sampling plot was converted to carbon stock after multiplication with the default value of carbon fraction 0.47 suggested by Ban Carbon Mapan Margadarsan, 2071 BS.

Result

Forest Characters

Hasantar Community Forest consists of total thirty one types of tree species of nineteen different families. Fagaceae and Moraceae have maximum number of species i.e four species in each. Families like Meliaceae, Pinaceae, Juglandaceae etc have one species in this forest. Family Fagaceae and Moraceae covers about 25.8% of trees species in the forest. (Fig.1 Table 1).

In HCF *Schima wallichii* was found most dominant and ecologically important tree species. The important value index of that species was found 65.92%. Similarly *Rhododendron arboreum* had 41.96% IVI value. Plants like *Pinus roxburghii, Pyrus pashia* and *Gaultheria fragrantissima* had least IVI value i.e. only about 5%. According to this study, the forest of HCF was found Schima- Rhododendron type of subtropical forest. (Fig; 2).

DBH Class of the Trees

The largest number of tree species in HCF was found in 21-30 cm DBH class. 31% of total trees were found in the DBH class 21-30 cm and only 1% of the trees were in DBH class <61 cm. (Fig. 3)

Table 1: List of all Tree species found in HCF

Serial no.	Local name of trees	Scientific name of trees	Family name
1	Bhalayo	*Rhus wallichii* sweet	Anacardiaceae
2	Lapsi	*Choerospondias axillaris* (Roxb.) B.L.Burtt LA.W.Hill	Anacardiaceae
3	Utish	*Alnus nepalensis* D. Don.	Betulaceae
4	Rudrakshya	*Elaeocarpus sphaericus* L.	Elaeocarpaceae
5	Aangeri	*Lyonia ovalifolia* (Wall.) Drude	Ericaceae
6	Gurans	*Rhododendron arboreum* Sm.	Ericaceae
7	Koiralo	*Bauhinia variegate* (L) Benth	Fabaceae
8	Tanki	*Bauhinia purpurea* L.	Fabaceae
9	Dhale Katush	*Castanopsis indica* A. Dc.	Fagaceae
10	Phalat	Quercus lantana Sm.	Fagaceae
11	Kharsu	*Quercus semicarpifolia* Roxb.	Fagaceae
12	Bajh	*Quercus incana* W. Bartram	Fagaceae
13	Mauwa	*Engelhardia spicata* Blume	Juglandaceae
14	Kutmero	*Litsea monopelata* Pers.	Lauraceae
15	Bakaino	*Melia azedarach* L.	Meliaceae
16	Rubber plant	*Ficus elastica* L.	Moraceae
17	Pipal	*Ficus religiosa* L.	Moraceae
18	Bar	*Ficus benghalensis* L.	Moraceae
19	Kimbu	*Morus alba* L.	Moraceae
21	Kaphal	*Myrica esculenta* Buch.-Ham. Ex D. Don	Myricaceae
20	Jamun	*Eugenia jambolana* Lam.	Myrtaceae
22	Bottle brush	*Callistemon lanceolatus* Curtis Skeels	Myrtaceae
23	Seti Kath	*Myrsine capitellata* Wall.	Myrsinaceae
24	Lakuri	*Fraxinus floribunda* Wall.	Oleaceae
25	Amala	*Phyllanthus emblica* L.	Phyllanthaceae
26	Pinus	*Pinus roxburgii* Sarg.	Pinaceae
27	Hade bayar	*Ziziphus incurva* Roxb.	Rhamnaceae
28	Mayal	Pyrus pashia Buch.-Ham.ex D.Don	Rosaceae
29	Paiyun	*Pyrus cerasoides* D.Don	Rosaceae
30	Chilaune	*Schima wallichii* (DC.) Korth	Theaceae
31	Jhingane	*Eurya acuminate* DC.	Thecaceae
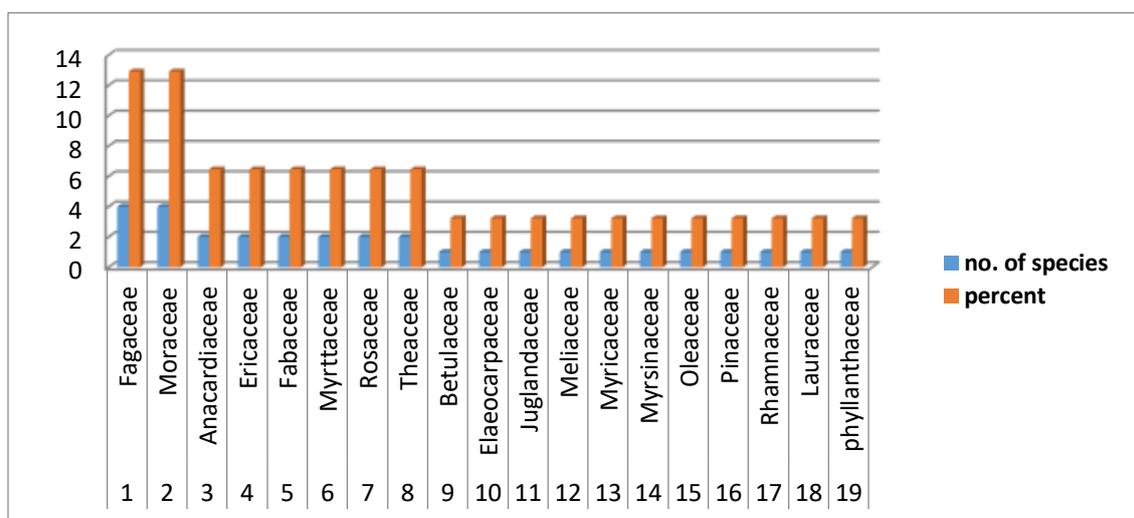
Fig. 1. Number of species in families
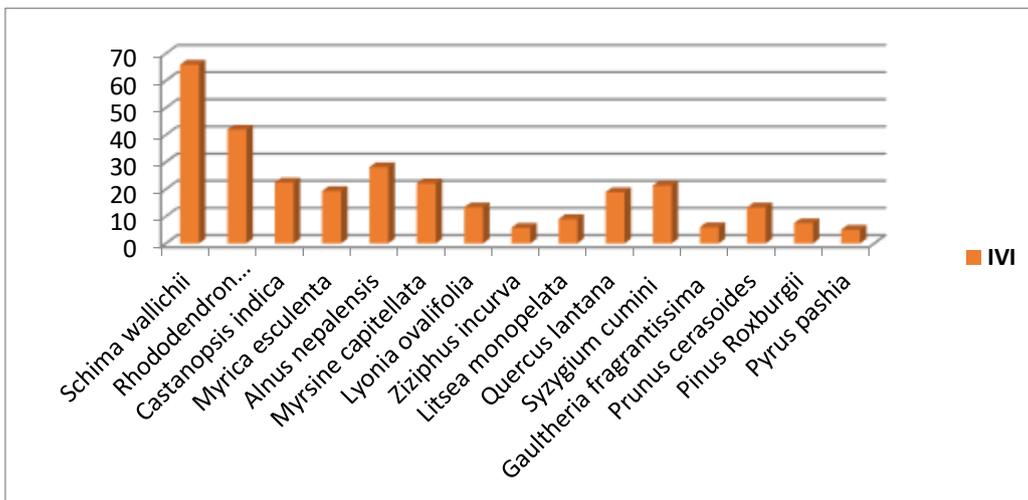
Fig. 2: Important value index of different species
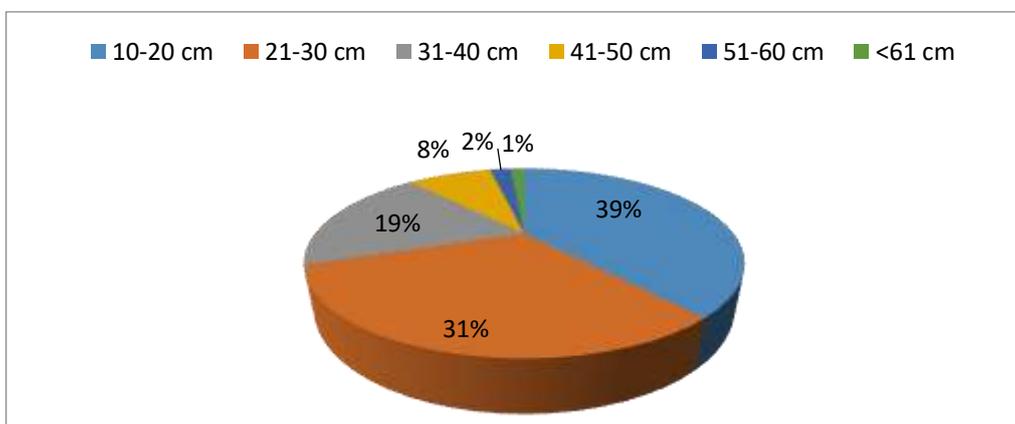
Fig. 3: Different DBH classes and their percentage
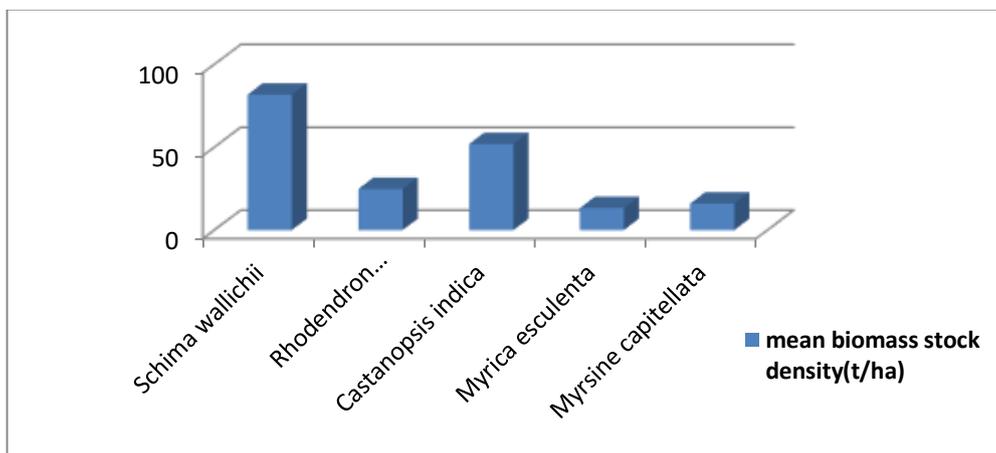
Fig. 4: Mean biomass density of five important species

Biomass Stock Density

Biomass represents the potential amount of carbon that could be added to the atmosphere as carbondioxide when the forest is cleared and burned. Biomass stock density estimation provides the means for calculating the amount of carbondioxide that could be removed from the atmosphere by vegetation. In HCF biomass stock density of *Schima wallichii* is found highest i.e. 81.722 t/ha. Biomass stock density of five dominant species of HCF is 187.811 t/ha. (Fig. 4)

Carbon Content in Different Tree Species

Carbon content in different species of trees was found different since their frequency, density, DBH (diameter at breast height) and height were different. *Schima wallichii* has highest carbon stock value and *Gaultheria fragrantissima* has lowest carbon stock value. (Fig. 5).
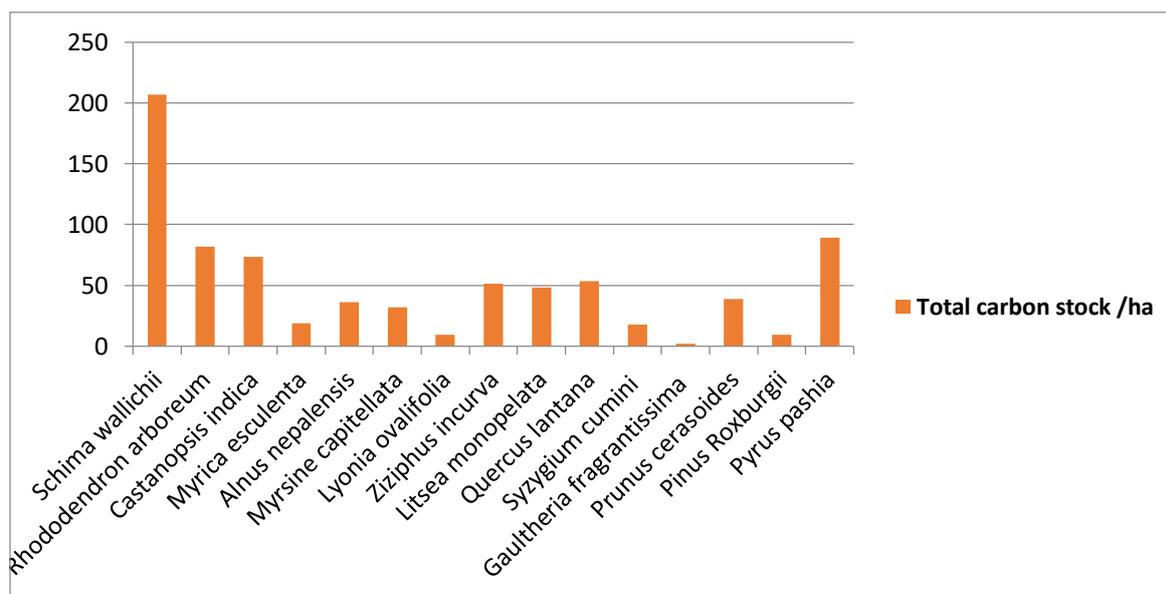
Fig. 5: carbon stock (t/ha) in different tree species

Discussion

Altogether thirty-one tree species of nineteen families and twenty-five genuses have been identified in HCF. The dominant tree species are *Schima wallichii, Rhododendron arboreum andMyrica esculenta*. Moraceae and Fagaceae have maximum number of Genus. The Important Value Index of any vegetation gives the idea about the importance of species. It helps to understand the dominance and ecological significance of species. In HCF, *Schima wallichii* is found most dominant and ecologically important tree species with highest IVI value. Biomass of a forest depends upon the condition of forest. The condition of forest is determined by the DBH class distribution. Classification of forests into timber trees, pole trees, and regeneration are made on the basis of DBH class distribution. The managed forests are most effective and reliable sinks of greenhouse gases. The local community has direct benefit sharing from the community forest. HCF is a community forest of Kathmandu where forest has been found as the pole stage according to their DBH type. The forest of Buffer zone Community Forest Kanchanpur consists of regenerating trees and pole size tree percentage is equal (Thagunna, 2009). Biomass density estimation provides the means for calculating the amount of carbon dioxide that could be removed from the atmosphere by growing forest. In HCF, the average above ground biomass of five dominant species is 187.811 t/ha. Thagunna, 2009 have found that the above ground biomass density of Bailbandha Community Forest, Kanchanpur was recorded as 26.03 t/ha. ICIMOD, 2016 the average total forest biomass of ICIMOD Knowledge Park was found 186.43 t/ha in 2014. The forest type of Knowledge Park is subtropical type similar as the forest of HCF. According to Forest Resource Assessment, DoFRS 2014, Forest carbon stock of Midhills forest is 157.80 t/ha.

HCF consists of similar types of vegetation and average above ground carbon stock is found 144.795 t/ha. Total carbon stock in tree species is found to be 144.795 t/ha which is comparable with 166.81 t/ha in Kumvakarna Conservation Community Forest, Ghunsa Taplejung (Jati, 2012). Similarly, Shrestha *et al*. (2016b) have been found that *Schima wallichii* of subtropical forest has highest carbon sequestrating rate than other trees. This study also found that *Schima walichii* has highest carbon sequestrating rate in HCF. The carbon stock value of trees in HCF is found lesser than the *Alnus nepalensis* forest where carbon stock was found 186.05 t/ha (Ranabhat et al, 2008).

Conclusion

This study provides current estimation of forest tree above ground biomass and carbon stock in the Hasantar Community Forest at Nagarjun Municipality Kathmandu. The common tree species of HCF are found as *Schima wallichii*, *Rhododendron arboreum, Myrica esculenta* etc. According to the vegetation parameters *Schima wallichii* was most dominant and ecologically significant tree species. The forest is found in pole stage according to their DBH value. The average above ground biomass of five dominant species is 187.811 t/ha and the average above ground carbon stock is found 144.795 t/ha.

Acknowledgement

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