

BIOMASS PRODUCTION AND CARBON STOCK POTENTIAL UNDER HOME GARDENS OF KASHMIR HIMALIYA

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Received-06.05.2019, Revised-24.05.2019

Abstract: Home garden agroforestry systems are suggested to hold large potential for climate change mitigation and adaption. This is due to their multifunctional role in providing income, food and ecosystem services while decreasing pressure on natural forests and hence saving and storing carbon, the study was designed to quantify biomass carbon stock and carbon sequestration potential under home gardens. The results of the study revealed in five tree crop combinations. The maximum (104.86 tha^{-1}) biomass production was found under treatment T₁ (Salix + Poplar + Beans + Kale + Apple) followed by (63.03, 59.53, and 52.48 tha^{-1}) in treatment T₃, T₄, and T₁, and minimum (44.53 tha^{-1}) in treatment T₁, where as carbon stock and carbon sequestration follows same trend as its simply the derivation of biomass. The results from this study will help to estimate levels of atmospheric CO₂ that could be sequestered by tree based land use systems for this climatic region of Kashmir Himalaya, therefore, an attempt has been made to collect the data on biomass, carbon stock and carbon sequestration potential in selected land use systems. The present findings may be used as baseline information for developing prediction models for probable effects of home gardens, future intervention and sustainable management in this region.

Keywords: Agroforestry, Land use system, Biomass, Carbon stock, Sequestration

INTRODUCTION

Home garden is commonly defined as; land use system involving deliberate management of multipurpose trees and shrubs in intimate association with annual and perennial agricultural crops and invariably livestock within the compounds of individual houses, the whole tree crop, and animal unit is being intensively managed by family labour (Kumar and Nair 2006). The most popular system in both the rural and urban areas owing to marginal land holdings were home garden agroforestry system. Home gardens in Ganderbal district represented a subsistence land-use system, where interaction and intimate association of different production components (crop-tree-pasture) in situ were intensively facilitated and managed by family labour so as not only to meet the food production but also to generate additional income through sale of farm surplus, this system is very vibrant with farmers who had land holdings of less than 0.1 ha, just in and around their dwellings or away from home. Farmers grow fruit and forest trees with cereals and vegetable crops during rabi and kharif seasons. The commonly found tree species in this system were *Salix alba*, *Populus deltoides*, *Populus nigra*, *Robinia pseudoacacia*, *Ailanthus altissima*, *Morus alba* at very close spacing in single or double rows. The fruit trees included pomegranate, apple, cherry, pear, almond, plum, peach and grapes Vegetables were grown in the interspaces of fruit trees and include Turnips, Radish, Cabbage, Spinach, Knol-khol, Kale, Garlic, Carrot, Onion, Potato, Beans, Chilli, Tomata and Brinjal.

Carbon dioxide increase is attributed mainly

combustion of fossil fuel and deforestation worldwide. The current atmosphere CO₂ concentration is 397.60ppm (NOAA).The CO₂ concentration and other greenhouse gases (GHGs) in the atmosphere have increased considerably and are set to rise further. Two environmental issues of the world today are climate change and biodiversity. Increase in atmospheric concentration of greenhouse gases (GHSs), of which most common is CO₂ is considered to be two primary cause of global climate change. Under the Kyoto protocols Article 3.3, A & R (afforestation and reforestation) with agroforestry as a part of it has been recognized as an option for mitigation greenhouse gases. As a result there is now increasing awareness on agroforestry potential for carbon sequestration (Nair et al. 2009, 2010).Fifth Assessment Report of Intergovernmental Panel on Climate change especially in developing countries of tropics to face the challenge of climate change (IPCC, 2014). The United Nations Frame work Convention on Climate of change defines carbon sequestration as the process of removing C from the atmosphere and depositing it over a long period in a reservoir. Sequestering C through agroforestry is now considered as attractive economic opportunity for mitigating global climate change and C trading in addition to providing multiple products. Projections of the world agroforestry center that the C market may exceed USS1 trillion by 2025 suggest that significant funds could potentially be generated through agroforestry interventions (WAC 2010).

MATERIALS METHODS

District Ganderbal is located on the north side of

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world famous Srinagar city of Kashmir valley at an elevation of 1650 to 3000 meters above Mean Sea Level (MSL). It is flanked by district Baramulla in the west, district Srinagar in the south, newly created district Bandipora in the north-west, Arohom forest in the north and district Kargil in the east. The district is located between 34.23°N Longitude and 74.78°E Latitude District Ganderbal consists of six tehsils Gund, Kangan, Ganderbal, Wakura, Lar, Tulmullah and seven blocks Lar, Ganderbal, Kangan, Wakura, Sheripathri, Safapora. It has been further divided into 112 panchayat halqas comprising 136 villages.

Climate

The climate of the region is moist temperate with mean annual precipitation of 730 mm received generally in the form of snow in winter and rains in March to June. The mean temperature of 13.3°C with maximum reaching upto 35°C in summer and may dip to -10°C in winter is generally experienced.

Home gardens of the district were evaluated for biomass production:

Tree biomass

- Plot size: 10 m × 10 m
- Above Ground Biomass (AGB) t/ha
- Stem biomass (t/ha)
- Branch biomass (t/ha)
- Leaf biomass (t/ha)

Crop Biomass (Rabi and kharif crops) kg/m²

Plot size: 1m × 1m

Litter biomass: Plot size: 1m×1m kg/m² (September-mid December)

Total biomass production= Tree + Crop+ Leaf t/ha

Stem biomass

The diameter at breast height (dbh) of the trees falling in the plot of size 10×10m was measured with diameter tape and height with Ravi's multimeter respectively. Form factor was calculated by using the Spiegel Relaskope to find out the volume using the formula given by Pressler (1854) and Bitterlich (1984):

$$f=2h_1/3h$$

Where,

f is the form factor, h₁= height at which diameter is half of dbh and h is the total height.

The volume (V) was calculated by Pressler's formula:

$$V = f \times h \times g$$

Where,

- f= form factor
- h=total height
- g=basal area, but $g=\pi r^2$ or $\pi (d/2)^2$ where, r = radius.

For further evaluation (i.e estimation of biomass and carbon stocks),

Tree biomass: (Tree biomass =stem biomass + canopy biomass)

Estimation of fruit stem biomass: The following biomass regression was used for estimating stem biomass per tree.

Fruit tree : $Y = \exp \{-2.4090 + 0.9522 \ln (D^2HS)\}$
(Brown *et al.*, 1989)

Where,

- Y = biomass per tree in kg,
- D = dbh in cm for trees and collar diameter for fruit trees,
- H = tree height in cm,
- S = wood density ($0.57 \text{ t m}^{-3} = \text{g cm}^{-3}$)

Estimation of biomass of canopy: for biomass estimation, the volume of the crown shall be multiplied by specific gravity (SG) as shown:

Canopy biomass = Canopy volume × specific gravity
The volume occupied by the canopy was estimated by:

$$\text{Crown volume (m}^3\text{)} = \frac{\pi Dh^2L}{12}$$

(Avery and Burkhardt, 2002)

Where,

Db = diameter (m) at the crown base

L = crown length

Estimation of below ground biomass: Below ground biomass of forest tree were estimated by using default value of 0.25 for converting above ground biomass into ground biomass,(Schulze,1983) and for fruit trees 0.33 were used for root biomass (Singh, 2010).For crop/grass actual measurements were recorded.

Branch biomass

The total number of branches irrespective of size was counted on each of the sample tree; the branches were categorized on the basis of basal diameter into three group's viz., small, medium and large. Fresh weight of two sampled branches from each group was recorded separately. The following formula (Chidumaya, 1990) was used to determine the dry weight of branches.

$$B_{dwi} = B_{fwi} / 1 + M_{cdbi}$$

Where,

B_{dwi}=oven dry weight of branches

B_{fwi}=Fresh/green weight of branches

M_{cdbi} =Moisture content of branches on oven dry weight basis

Total branch biomass (fresh/dry) per sample tree was determined as given below:

$$B_{bi} = n_1bw_1 + n_2bw_2 + n_3bw_3, \dots =$$

Where,

B_{bi}=Branch biomass (fresh/dry) per tree

n_i=Number of branches in the ith branch group

B_{wi}= Average weight of branch of ith group

I=1, 2, 3,.....the branch groups.

Leaf biomass

The leaf biomass was measured by categorizing the branches of sample tree on the basis of basal diameter into three groups viz., small medium and large. The leaf biomass of all the representative branches of sample trees in each diameter class were determined just after removing them from branch and then calculate the leaf biomass of the whole 10 × 10 m quadrat. The leaf samples were placed in separate

bags and oven dried at 65±5°C for period of 72 hours or till the weight became constant (Chapman, 1964)

Specific gravity

The stem cores were taken to find out specific gravity which was used further to determine the biomass of stem using the maximum moisture method (Smith, 1954).

$$G_f = \frac{1}{\frac{M_n - M_0}{M_0} + \frac{1}{GS_0}}$$

Where,

G_f = specific gravity based on gross volume

M_n = weight of saturated volume sample

M_o = weight of oven dried sample

G_{so} = Average density of wood substance equal to 1.53

Thus,

Weight of stem wood = specific gravity × volume

Or

Biomass = specific gravity × volume

RESULTS AND DISCUSSION

Baseline data in (Table 1) revealed that in home gardens a total of five tree-crop combinations have been studied viz., T₁ (Poplar + Kale + Beans + Apple), T₂ (Poplar + Kale +Chilli + Apple), T₃(Poplar + Turnip + Beans + Apple),T₄ (Salix + Radish + Beans + Pear), and T₅ (Salix + Poplar + Beans + Kale + Apple) respectively. In treatment (T₅) the maximum average height of Poplar and Salix was 27.7 (m) and 12.0 (m) respectively whereas their dbh, was recorded as 73.0 cm and 45 (cm) respectively. The number of Poplar and Salix trees ha⁻¹ was 280 and 20 respectively, the average height of apple trees, collar diameter and the number of trees ha⁻¹ was 5.53 (cm) ,30.67 (cm) and 200 respectively. The total number of trees ha⁻¹ was 500,where as in treatment T₁, the minimum average height, dbh and number of trees of Poplar trees in treatment T₁ was 23.0 (m) dbh 72.0 (cm) and 200 respectively, whereas the average height, collar diameter and number of trees of apple trees was 5.54 (m), 20.5(cm) and 100 respectively. And total number to trees per hectare was 300. Data pertaining to Biomass in Home gardens has been given in (Table 2) clearly showed that maximum stem biomass was recorded as 67.32 tha⁻¹ in treatment T₅ followed by treatment T₃ in which the stem biomass was recorded 35.88 tha⁻¹, 27.7 tha⁻¹ in treatment T₄ and 27.63 tha⁻¹ in treatment T₂. The biomass of the different above ground components depends upon the number factors, viz., stem, branch, canopy, and leaf depends upon the number of factors, growth habit of the species, site quality, soil on which trees are growing, stand age, management practices and their interactions with below ground components.(Niu and Duiker 2006; Jana et

al.2009).The biomass is directly linked to tree density: as its minimum in treatment T₁ and maximum in treatment T₅ especially Poplar trees where the number was 280 ha⁻¹.

Minimum biomass was recorded as (24.41tha⁻¹) in treatment T₁ (Poplar + Kale + Beans + Apple). The branch biomass 0.51(minimum), 0.6, 0.98, 0.69 and 2.60tha⁻¹ (maximum) in T₁, T₂, T₃, T₄ and T₅ respectively. The maximum leaf biomass was recorded as 1.31(tha⁻¹) in treatment T₅ whereas its minimum biomass recorded as 0.012 in treatment T₄ (Salix+Radis+Beans+Pear). The treatment T₅ recorded maximum above and below ground biomass was recorded as 71.22 and 17.80 tha⁻¹ respectively, whereas minimum AGB and BGB was 25.01 and 6.25 tha⁻¹ respectively in treatment T₁.The maximum total biomass was recorded as 89.02 tha⁻¹ in treatment T₅ whereas minimum biomass was recorded as 31.29tha⁻¹in treatment T₁ (Poplar + Kale + Beans + Apple).

In fruit tree biomass, the maximum stem biomass was recorded was (5.00tha⁻¹) in treatment T₅ followed by treatment T₄ in which stem biomass was recorded as 6.9 tha⁻¹, minimum stem biomass was recorded as 2.38 tha⁻¹ in treatment T₁.The canopy biomass as 0.72 tha⁻¹ (minimum), 1.8, 1.1, 2.7 and 1.35 tha⁻¹ (maximum) in treatment T₁, T₂, T₃, T₄, and T₅ respectively in treatment T₁.The treatment T4 recorded maximum above and below ground biomass as 6.35 and 3.16 tha-1 whereas minimum (3.1 and 1.02tha⁻¹) above and below ground biomass was recorded in Treatment T₁. The maximum total fruit tree biomass (8.44tha⁻¹) in treatment T₅ and minimum biomass as (4.12tha⁻¹) in treatment T₁.

The maximum rabi crop bio biomass was observed 6.14 tha⁻¹ in treatment T₄ followed 5.71, 5.21 and 5.13 tha⁻¹ in treatment T₃, T₅ and T₂, whereas minimum rabi crop biomass 5.10 tha⁻¹ was observed in treatment T₁. Maximum kharif crop biomass 5.77 tha⁻¹ was observed in treatment T₃ (Poplar +Turnip+ Beans + Apple) followed by 5.13, 4.02 and 2.19tha⁻¹ in treatment T₄, T₁ and T₅ whereas minimum kharif crop biomass 2.11 tha⁻¹ was observed in treatment T₂. The total maximum biomass production under home garden was observed 104.6 tha⁻¹ in treatment T₅, followed by 63.03tha⁻¹ in T₃, 59.53 tha⁻¹ in T₄, 52.48 tha⁻¹ in T₂ while minimum biomass 44.53tha⁻¹ was recorded in treatment T₁.

Carbon stock refers to the absolute quantity of C held at the time of Inventory, whereas C sequestration refers to the process of removing carbon from the atmosphere and depositing it in a reservoir (Takimoto et al. 2008). Data pertaining to Carbon stock in Home gardens has been given in (Table 3) clearly showed that maximum stem carbon was recorded as 30.29 tha⁻¹ in treatment T₅ followed by treatment T₃ in which the stem carbon stock was recorded 16.14 t ha⁻¹, 12.46 t ha⁻¹ in treatment T₄ and 12.43tha⁻¹ in treatment T₂. Minimum biomass was recorded as 10.98 t ha⁻¹ in treatment T₁. Mattsson et

al (2013) estimated the carbon stock for dry zone Sri Lankan homegardens (Hambantota and Anuradnapura district) is ranging from 10 to 55 Mega grams of carbon per hectare (Mg C ha^{-1}) (mean 35 Mg C ha^{-1}) The branch carbon stock 0.22 (minimum), 0.27, 0.44, 0.31 and 1.17 tha^{-1} (maximum) in T_1 , T_2 , T_3 , T_4 and T_5 respectively. The maximum leaf carbon was recorded as 0.58 tha^{-1} in treatment T_5 whereas its minimum biomass recorded as 0.005 tha^{-1} in treatment T_4 . The treatment T_5 recorded maximum above and below ground carbon stock was recorded as 32.04 and 8.01 tha^{-1} respectively, whereas minimum AGB and BGB was 11.26 and 2.81 tha^{-1} respectively in treatment T_1 . The maximum total carbon was recorded as 40.05 tha^{-1} in treatment T_5 whereas minimum carbon was recorded as 14.08 tha^{-1} in treatment T_1 . Carbon concentration was highest in stem followed by branches and leaves. A similar trend in carbon stock was also observed by Negi et al. (2003) and jana et al. 2009 in dry tropical forests in India.

In fruit tree carbon stock, the maximum stem carbon was recorded was 3.10 tha^{-1} in treatment T_4 followed by treatment T_2 in which stem carbon was recorded as 2.52 tha^{-1} , minimum stem carbon was recorded as 1.07 tha^{-1} in treatment T_1 . In treatment T_2 , T_3 and T_5 the carbon stock was recorded as 2.52 , 1.30 and 2.25 tha^{-1} respectively. The canopy carbon as 0.32 tha^{-1} (minimum), 0.81 , 0.49 , 1.21 and 0.60 tha^{-1} (maximum) in treatment T_1 , T_2 , T_3 , T_4 , and T_5 respectively. The treatment T_4 recorded maximum above and below ground carbon as 4.31 and 1.42 tha^{-1} whereas minimum (1.39 and 0.45 tha^{-1}) above and below ground carbon was recorded in Treatment T_1 . The maximum total fruit tree carbon (3.89 tha^{-1}) in treatment T_4 and minimum biomass as (1.85 tha^{-1}) in treatment T_1 .

The maximum rabi crop carbon stock was observed

2.76 tha^{-1} in treatment T_4 followed 2.54 , 2.34 and 2.30 tha^{-1} in treatment T_3 , T_5 and T_2 , whereas minimum rabi crop biomass 2.29 tha^{-1} was observed in treatment T_1 . Maximum kharif crop carbon 2.59 tha^{-1} was observed in treatment T_3 (Poplar + Turnip + Beans + Apple) followed by 2.30 , 1.80 and 0.98 tha^{-1} in treatment T_4 , T_1 and T_5 whereas minimum kharif crop carbon 0.94 tha^{-1} was observed in treatment T_2 . The total maximum carbon stock production in Home gardens was observed 47.16 tha^{-1} in treatment T_5 , followed by 28.34 tha^{-1} in T_3 , 26.77 tha^{-1} in T_4 , 23.59 tha^{-1} in T_2 while minimum carbon 20.02 tha^{-1} was recorded in treatment T_1 . data pertaining to CO_2 mitigation potential in Home gardens has been given in (4) clearly follows same trend as that of biomass and carbon stock as it is carbon sequestration is derivation of carbon stock.

CONCLUSION

The results of this study show that home gardens in Kashmir region have high potential to store biomass and hence carbon sequestration, with an average biomass 64.85 tha^{-1} and have a potential to sequester 107.03 tha^{-1} of carbon. The carbon estimates found here are reflecting the differences in tree density, tree diversity and management practices between individual home gardens. Smaller home gardens hold higher carbon content and tree diversity than medium and large home gardens. To meet the future challenges of land and water scarcity, and to ensure food security as a results of climate change, future mitigation and adaption strategies that may be used by local land users through effective support by stakeholders and policy makers needs further attention. to identify such strategies, its relevance to analyze quantitative information and estimates in temperate home gardens.

Table 1. Base line data of Home gardens.

Tree crop combinations	Forest tree, Fruit tree and Crop components in rotation	Forest tress				Fruit trees No. of trees			Total no. of trees ha^{-1}	
		Av. height of forest trees(m)	dbh (cm)	No. of trees ha^{-1}	Av. height of fruit trees(m)	Collar diameter(cm)	No. of trees ha^{-1}			
T_1	Poplar + Apple + Kale-Beans	23.0 ± 3.94	72.0 ± 6.8	200	5.45 ± 0.55	20.5 ± 3.18	100	300		
T_2	Poplar + Apple + Kale-Chilli	26.0 ± 2.0	67.6 ± 6.4	200	4.60 ± 0.60	53.5 ± 2.5	200	400		
T_3	Poplar+ Apple + Turnip-Beans	17.3 ± 4.63	54 ± 0.14	300	4.80 ± 0.49	69.0 ± 4.00	100	400		
T_4	Salix+ Pear + Radish-Beans	11.0 ± 0.57	47.3 ± 2.02	300	4.43 ± 0.22	25.0 ± 3.05	300	600		
T_5	Poplar+ Salix + Apple + Kale+ Beans	27.7 ± 8.3	12.0 ± 1.25	73.0 ± 14.3	45.0 ± 11.1	$280 + 20 = 300$	5.53 ± 0.73	30.67 ± 8.21	200	500
Mean \pm SE		23.4 ± 4.78	71.6 ± 4.4	260 ± 24.49	4.96 ± 0.22	39.4 ± 9.3	260 ± 24.49	440 ± 50.99		

Table 2. Average biomass production (tha⁻¹) under Home gardens. (Pooled data for the years 2015 & 2016)

Tree crop combinations	Biomass of forest trees						Biomass of fruit trees					Crop biomass		Total biomass
	Stem	Branch	Leaf	Above ground	Below ground	Total	Stem	Canopy	Above ground	Below ground	Total	Rabi	Kharif	
T ₁	24.41 ± 0.71	0.51 ± 0.14	0.12 ± 0.003	25.04 ± 0.72	6.25 ± 0.18	31.29 ± 0.90	2.38 ± 0.068	0.72 ± 0.020	3.1 ± 0.092	1.02 ± 0.028	4.12 ± 0.12	5.10 ± 0.029	4.02 ± 0.01	44.53 ± 1.23
T ₂	27.63 ± 0.79	0.6 ± 0.17	0.09 ± 0.002	28.32 ± 0.081	7.08 ± 0.20	35.4 ± 1.02	5.6 ± 0.016	1.8 ± 0.051	7.4 ± 0.21	2.44 ± 0.070	9.84 ± 0.28	5.13 ± 0.072	2.11 ± 0.05	52.48 ± 1.51
T ₃	35.88 ± 1.03	0.98 ± 0.028	0.13 ± 0.004	36.99 ± 1.06	9.24 ± 0.26	46.23 ± 1.33	2.9 ± 0.08	1.1 ± 0.031	4.0 ± 0.11	1.32 ± 0.37	5.32 ± 0.15	5.71 ± 0.11	5.77 ± 0.13	63.03 ± 1.81
T ₄	27.7 ± 0.79	0.69 ± 0.019	0.012 ± 0.034	28.40 ± 0.82	7.10 ± 0.20	35.50 ± 1.02	6.9 ± 0.19	2.7 ± 0.08	9.6 ± 0.27	3.16 ± 0.08	12.76 ± 0.36	6.14 ± 0.074	5.13 ± 0.06	59.53 ± 1.71
T ₅	67.32 ± 1.94	2.60 ± 0.0075	1.3 ± 0.037	71.22 ± 2.05	17.80 ± 0.51	89.02 ± 2.56	5.00 ± 0.11	1.35 ± 0.07	6.35 ± 6.19	2.09 ± 0.066	8.44 ± 0.25	5.21 ± 0.017	2.19 ± 0.04	104.86 ± 3.04
Mean ± SE	36.58 ± 7.91	1.07 ± 0.38	0.33 ± 0.24	37.98 ± 8.53	9.49 ± 2.13	47.47 ± 4.8	4.55 ± 0.84	1.53 ± 0.078	6.08 ± 1.17	2.00 ± 0.38	8.08 ± 1.55	5.43 ± 0.21	3.84 ± 0.81	64.85 ± 10.71

(T₁) Poplar + Kale + Beans + Apple, (T₂) Poplar + Kale + Chilli + Apple,
 (T₃) Poplar + Turnip + Beans + Apple, (T₄) Salix + Radish + Beans + Pear,
 (T₅) Salix + Poplar + Beans + Kale + Apple

Table 3. Average carbon stock (tha⁻¹) under Home gardens. (Pooled data for the year 2015 & 2016)

Tree crop combinations	Carbon stock of forest trees						Carbon stock of fruit trees					Crop carbon stock		Total carbon stock
	Stem	Branch	Leaf	Above ground	Below ground	total	Stem	Canopy	Above ground	Below ground	total	Rabi	Kharif	
T ₁	10.98 ± 0.33	0.22 ± 0.007	0.054 ± 0.0016	11.26 ± 0.32	2.81 ± 0.08	14.08 ± 0.40	1.07 ± 0.031	0.32 ± 0.009	1.39 ± 0.40	0.45 ± 0.14	1.85 ± 0.54	2.29 ± 0.01	1.80 ± 0.006	20.02 ± 0.55
T ₂	12.43 ± 0.35	0.27 ± 0.008	0.040 ± 0.0012	12.74 ± 0.36	3.18 ± 0.091	15.93 ± 0.45	2.52 ± 0.072	0.81 ± 0.026	3.33 ± 0.095	1.09 ± 0.017	4.42 ± 0.12	2.30 ± 0.03	0.94 ± 0.02	23.59 ± 0.67
T ₃	16.14 ± 0.46	0.44 ± 0.012	0.058 ± 0.002	16.64 ± 0.48	4.15 ± 0.84	20.80 ± 0.61	1.30 ± 0.037	0.49 ± 0.014	1.8 ± 0.051	0.59 ± 0.017	2.39 ± 0.09	2.56 ± 0.05	2.59 ± 0.06	28.34 ± 0.81
T ₄	12.46 ± 0.36	0.31 ± 0.008	0.0054 ± 0.0047	12.78 ± 0.32	3.19 ± 0.84	15.97 ± 0.46	3.10 ± 0.89	1.21 ± 0.034	4.31 ± 0.121	1.42 ± 0.041	5.74 ± 0.66	2.76 ± 0.03	2.30 ± 0.02	26.77 ± 0.77
T ₅	30.29 ± 0.87	1.17 ± 0.033	0.58 ± 0.017	32.04 ± 0.95	8.01 ± 0.23	40.05 ± 1.15	2.25 ± 0.051	0.60 ± 0.033	2.85 ± 0.89	0.94 ± 0.028	3.79 ± 0.11	2.34 ± 0.01	0.98 ± 0.42	47.16 ± 1.36
Mean ± SE	16.46 ± 3.55	0.48 ± 0.042	0.14 ± 0.10	17.09 ± 3.84	4.26 ± 0.96	21.36 ± 4.8	2.04 ± 0.37	0.68 ± 0.15	2.73 ± 0.52	0.89 ± 0.17	3.63 ± 0.71	2.45 ± 0.26	1.72 ± 0.34	29.17 ± 4.81

(T₁) Poplar + Beans + Kale + Apple, (T₂) Poplar + Kale + Chilli + Apple,
 (T₃) Poplar + Turnip + Beans + Apple, (T₄) Salix + Radish + Beans + Pear,
 (T₅) Salix + Poplar + Beans + Kale + Apple

Table 4. Average potential of Home gardens for CO₂ mitigation (tha⁻¹). (Pooled data for the year 2015 & 2016)

Tree crop combinations	CO ₂ mitigation Forest trees						CO ₂ mitigation Fruit trees					Crop mitigation CO ₂		Total CO ₂ mitigation
	Stem	Branch	Leaf	Above ground	Below ground	Total	Stem	Canopy	Above ground	Below ground	Total	Rabi	Kharif	
T ₁	40.29 ± 1.16	0.80 ± 0.030	0.19 ± 0.0064	41.28 ± 1.19	10.31 ± 0.72	51.60 ± 1.49	3.92 ± 1.15	1.17 ± 0.03	5.09 ± 0.14	1.66 ± 0.055	6.75 ± 0.19	8.43 ± 0.04	6.60 ± 0.02	73.38 ± 2.03
T ₂	45.61 3± 1.31	0.99 ± 0.032	0.14 ± 0.007	46.74 ± 1.34	11.67 ± 0.33	58.41 ± 1.68	9.24 ± 0.26	2.97 ± 0.09	12.21 ± 0.35	4.02 ± 0.60	16.23 ± 2.85	8.44 ± 0.11	3.49 ± 0.09	86.57 ± 2.49
T ₃	59.23 ± 1.71	1.61 ± 0.041	0.21 ± 0.007	61.05 ± 1.76	15.23 ± 0.44	76.30 ± 2.21	4.77 ± 0.14	1.79 ± 0.055	6.56 ± 0.19	2.16 ± 0.060	8.72 ± 0.35	9.43 ± 0.18	9.51 ± 0.22	103.99 ± 3.01
T ₄	45.72 ± 1.32	1.13 ± 0.032	0.018 ± 0.01	46.86 ± 1.36	11.70 ± 3.11	58.60 ± 1.69	11.37 ± 0.32	4.44 ± 0.17	15.81 ± 0.44	5.21± 1.14	21.02 ± 0.61	10.12 ± 0.12	8.48 ± 0.10	98.23 ± 2.84
T ₅	111.16 ± 3.32	4.29 ± 0.12	2.12 ± 0.064	117.58 ± 3.39	29.39 ± 0.84	146.98 ± 4.24	8.25 ± 0.19	2.20 ± 0.12	10.45 ± 6.32	3.44 ± 0.106	13.89 ± 0.42	8.59 ± 0.028	3.59 ± 1.56	173.06 ± 5.02
Mean ± SE	60.41 ± 29.30	1.76 ± 0.64	0.52 ± 0.03	62.72 ± 14.09	15.66 ± 3.52	78.38 ± 17.61	7.50 ± 1.39	2.50 ± 0.56	10.02 ± 1.19	3.29 ± 0.63	13.32 ± 2.57	8.99 ± 0.35	6.33 ± 1.26	107.03 ± 17.68

(T₁) Poplar + Beans + Kale+ Apple, (T₂) Poplar + Kale+ Chilli + Apple,

(T₃) Poplar +Turnip+ Beans + Apple, (T₄) Salix + Radish + Beans + Pear, (T₅) Salix + Poplar +Beans + Kale + Apple

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