EP NO 15/ 2022-23 ASSESSING THE CARBON SEQUESTRATION POTENTIAL IN DIFFERENT FOREST PLANTATIONS IN TAMIL NADU

INTRODUCTION

Since the industrial revolution, there has been drastic increase in the concentration of atmospheric carbon dioxide and other greenhouse gases (GHGs). The major reasons attributed to the global warming and associated climatic changes are increased concentration of GHGs in the atmosphere. The global atmospheric CO2 concentration increased from 280 ppm in 1750 to 404.39 ppm in August, 2016 which has been attributed primarily to fossil fuel use and land-use change with a total increase of 1.9 ppm per year. Current strategies for coping with global warming include reducing fossil fuel combustion, carbon sequestration by vegetation (Trees). Trees are among the most important and common sinks for atmospheric carbon. Natural forests, forest plantations, agro forestry practices and some other agricultural activities act as a sink for carbon dioxide (CO2) through photosynthesis and store carbon as biomass. Atmospheric carbon can be sequestered in long-lived carbon pools of plant biomass both above and below ground and soil organic carbon. According to the Kyoto protocol, only carbon newly sequestered through agroforestry practices is considered as carbon credits and can be sold to industrialized countries to meet their emission reduction targets. Information on carbon sequestration under natural forest and various land-use systems is very meager. Therefore, this study aims to quantify carbon sequestration potential in all available forms of forest plantations in different parts of Tamil Nadu.

OBJECTIVES:

1. To analyse the above and below ground biomass of selected agro-forestry system from two agroclimatic zones of Tamilnadu.
2. To estimate the biomass carbon accumulation in agroforestry land use system of selected tree species.
3. To ascertain the soil organic carbon content in agroforestry models.
4. To impart training cum workshop on tree carbon sequestration to Deparment officials.

OBSERVATIONS TO BE RECORDED:

1. The Geo coordinates of the plantation sites have been recorded
2. Growth data of the plantation has been recorded
3. The total biomass, above ground biomass ,below ground biomass have been recorded.
4. The soil organic carbon content in the sieved soil sample has been recorded.
5. Photographs have been taken to study the changes in growth characters

MATERIALS AND METHODS

1. Materials

Teak and Mahogany based pure stand and agroforestry based plantations has been selected for the study but intercrop not planted in the many of the fields. In this reason pure stand only taken for the study. Farmer's Plantations of *Tectona grandis and Switenia macrophylla* species of different age class has been identified through a preliminary survey in North Western districts namely Dharmapuri, Krishnagiri, Salem and Namakkal. Planting details such as area and age of the plantations has been collected from the forest plantation register of Tamil Nadu Forest department and through farmer's information. An identified plantation has been categorized into different age classes**(Table 1)**. Morphological data (plant height and girth at breast height) of the teak and mahagony has been collected through random sampling method.

Soil sample from sample plots has been collected according to procedure given in the IPCC guidelines (IPCC, 1997). The soil samples has been collected randomly from all the sample plots by digging a fresh rectangular pit in the native vegetation and by clearing the top layer of grass, litter and humus in an area of 50 cm x 50 cm. However, no samples has been taken from eroded land, or from near the trunk of trees, roads. The soil samples has been collected at the depth of 0-15 cm (surface), 15-30 cm (sub surface) and 30-45 cm (deep layer)layers separately, dried and powdered using wooden mallet and sieved through 2 mm sieve. 3 No's of soil samples was collected from a plantation and a total of 210 samples were collected to study the soil carbon content.

2. METHODS

a) Sampling plots and data collection

The sampling in these plantations has been decided based on the size of the experimental plot. Sample plot of desired size (10% sampling intensity) has been placed randomly in the field and the biomass carbon was estimated. 10 No's of plantation for each age gradation has been selected and a total of 7 age gradations has been taken for the study.

Morphological data of each tree in the Sampling plots has been measured to find out the average growth of trees. Mean growth attributes of each Sampling plots has been tabulated under the respective age classes.**(Table 2).**

b) Biomass Estimation

Biometric evaluation of selected tree seedlings

To assess the growth rate of the planted tree seedlings, the following biometric observations has been recorded at 3 months interval and only final interval (March) data taken for the analysis.

- Height (m)
- Diameter (cm)

Height

From ground level to shoot tip of the tree, the plants height was measured in meters (m) using a measuring tape.

Diameter

At 1.37m height (breast level) of standing tree, diameter of the tree was measured in centimeters (cm) using a measuring tape.

Volume estimation

The volume of tree seedlings was estimated using the following formula (Chaturvedi and Khanna, 1982) and expressed in cubic centimetre (m^3).

$$V = \pi r^2 h$$

Where,

V= Volume

r = Radius

h = Total height

Estimation of biomass in planted tree seedlings

The biomass of the planted seedlings has been estimated using non destructive sampling method. The biomass was calculated for the entire plant as described below.

i. Above Ground Biomass
ii. Below Ground Biomass
iii. Total Biomass

Above Ground Biomass (AGB)

The biomass was calculated as per the formula given below by Pandya*et al.,* (2013)

$$AGB\ (kg/tree) = Volume\ of\ tree\ (m^3) \times Wood\ density\ (kg/m^3)$$

Note: The wood density of tree species not be available for all species; hence the standard average value 0.6 gm/cm^3has been taken for study.

Below Ground Biomass (BGB)

Below Ground Biomass of the planted tree seedlings was estimated by non destructive method. Below Ground Biomass includes all biomass of live roots excluding fine roots having < 2 mm diameter. The Below Ground Biomass is calculated by multiplying AGB by 0.26 factors as the root: shoot ratio. Below Ground Biomass was calculated by following formula:

Below Ground Biomass (Kg/tree) or (ton/tree) = AGB (Kg/tree) or (ton/tree) x 0.26

Pandya*et al.,* (2013)

Total Biomass

Total biomass of trees includes both above ground and Below Ground Biomass of the tree was calculated by following method (Ravindranath and Ostwald, 2008).

Total Biomass (Kg/tree) or (ton/tree) = AGB + BGB

B) Biomass Carbon Estimation

The biomass carbon content of planted tree seedlings was calculated by utilizing the arithmetic value of biomass attained.

Carbon Storage = Biomass x 50 % (or) Biomass / 2 (Suryawanshi*et al.*, 2014)

C) Soil Organic Carbon The soil organic carbon content in the 2 mm sieved soil samples was estimated as per Walkley and Black's wet oxidation method (Walkley and Black, 1934) and a result has been expressed in percentage.

RESULTS / FINDINGS

Volume

The study was conducted across the state of Tamil Nadu and totally 7 different age plantations selected for the study (6 Teak different age plantations and 1 Mahagony plantation) and biometric data was recorded. The results reported that there was a significant difference in the carbon content (C) in above ground biomass between the ages of plantations. The total carbon content in average volume of per tree of teak plants ranged from 0.04 m^3 in 6 year old plantation to 0.105 m^3 in 11 year old plantation. **(Table 2)**

In respect to Mahogany plantation the average volume of one year old tree was 0.003 m^3/ tree. The results indicated that the volume of the plantation has increased with an increase of girth, height and age of the plantation. **(Table 2)**

Above Ground Biomass

The results reported that there was a significant difference in the above ground biomass between the ages of plantations. The average Above Ground Biomass of per tree ranged from 22.59 kg/tree in 6 year old plantation to 62.40 kg/tree in 11 year old plantation. The data depicted that the Above Ground Biomass has increased with an increase of age of the plantation.**(Table 2)**

In respect to Mahagony plantation, the average Above Ground Biomass of one year old tree was 1.852 kg/tree. **(Table 2)**

The result of present study was in accordance with the result of Ravi *et al.,*(2012) in *Casuarina equsetifolia*, revealed that above ground biomass of the different age plantation was increased from 33.48 per cent to 47.48 per cent between 1 and 5 yr old plantations**(Table 2)**.

Below Ground Biomass

The below ground biomass carbon *viz*., root carbon content of teak trees of different age gradations was estimated. The average below ground biomass content of per tree ranged from 5.87 kg/tree in 6 year old plantation to 16.22 kg/tree in 11 year old plantation trees. **(Table 2)**

In respect to Mahagony plantation, the average Below Ground Biomass of one year old tree was 0.482 kg/tree.**(Table 2)**

Total Biomass

Increased establishment of tree plantations on degraded lands due to anthropogenic problems in the tropics has long been suggested as a way of reducing the rate of increase in atmospheric CO_2 (Dyson,1977). The results observed that there was a significant difference in average total biomass carbon of per tree between ages of plantations. The total biomass content of per tree ranged from 28.46 kg/tree in 6 year old plantation to 78.63 kg/tree in 11 year old plantation. It was noticed that there was a gradual increase in total biomass with an increase of age.**(Table 2)**

In respect to Mahagony plantation, the average Total Biomass of one year old tree was 2.334 kg/tree. **(Table 2)**

Soil Organic Carbon (%)

Carbon is sequestered in the part of the soil called humus, which provides more stable storage of carbon than biomass. Humus is made up of a collection of organic matter that results from decomposition of animal and vegetative litter. Soil organic carbon plays a very important role in maintenance and improvement of soil properties as well as nutrient status of soil. The organic carbon concentration of the soil showed wide variation across the land use system.

The capacity of a soil to sequester organic carbon is dependent mainly on climate, soil type and landscape, types of vegetation and soil management imposed by agriculture practices. The results showed that the per cent soil organic carbon of Teak plantations differed between ages. The maximum soil organic carbon in the surface layer (0-15 cm) of soil with a value of 1.28 per cent was recorded under 5 yearold plantations (2017-18) and minimum (0.54%) under 11 years old plantation (2012-13). An increasing trend of values was observed with decrease in age.**(Table 3)**

In respect to sub surface layer (15-30 cm) the maximum soil organic carbon was found in 5 year old plantation (2017-18) with value of 1.03 per cent and minimum (0.30%) under 11 year old plantation (2012-13). In respect to deep layer (above 30 cm) the maximum soil organic carbon was found in 5 year old plantation (2017-18) with value of 0.53 per cent and minimum (0.23%) under 11 year old plantation (2012-13)**(Table 3)**. In all soil layers the percent of organic carbon increasing trend of values was observed with decrease in age. Among the three types of soil layers surface layer of soil had registered high soil organic carbon percent and deep layer above (30 cm) had registered lowest soil organic carbon percent.

In respect to Mahogany plantation the surface soil layer (0-15 cm) had registered highest soil organic percent and deep layer (above 30 cm) had registered lowest soil organic percent. **(Table 3)**

Many research findings revealed that soil organic carbon percent increases with increase trend of age of the plantation because due to accumulation of leaf litter and other residues of plant matter which increases the soil humus and organic matter but the present study findings revealed that soil organic carbon percent increases with decrease in the age of the plantation. Application of high rates of chemical or inorganic fertilization and intensive crop rotation systems have may be the reason for decreases in soil organic carbon.

Total Carbon

Plants and the pedosphere can be the effective sinks for carbon (Divya*et al*., 2022). The potential of pedosphere to sequester carbon can play an important role

in the overall management of carbon (Poutter and Klooster, 1997). The calculated total carbon in different age of teak plantation was lower in 6 year old plantation with a value of 14.23 kg/tree and higher in 11 year old plantation with a value of 39.31 kg/tree. **(Table 2)**

In respect to Mahagony plantation, the average total carbon sequestrated potential of one year old tree was 0.482 kg/tree. **(Table 2)**

In respect to CO_2 sequestrated potential of Teak plantations varied with different ages. The calculated total carbon in different age of teak plantation was lower in 6 year old plantation with a value of 52.23 kg/tree and higher in 11 year old plantation with a value of 144.30 kg/tree. **(Table 2)**

In respect to Mahagony plantation, the average total CO_2sequestrated potential of one year old tree was 4.28 kg/tree. With regard to carbon sequestration potential both the species have high carbon and carbon-di-oxide sequestrated potential as whole and among the two species Teak has high carbon sequestrated compared to Mahogany in respect growth rate and wood density of tree species.

Conclusion

Soil and vegetation therefore represent potential sinks for carbon sequestration. Several authors have suggested afforestation as a possible means of mitigating global climate change (Jogattappa*et al*., 2020). This present study revealed carbon sequestration potential increases with increasing morphological characters and age of the plantation. From the present study, it was found that Teak and Mahogany plantations have sequestered significant amount of carbon in different components of trees. So, the plantations are of paramount importance in the reduction of ambient carbon dioxide levels and mitigation of global climate change.

Table 1: Plantation details

S. No	Year of plantation	Plantation name
1.	2012-13	Teak
2.	2014-15	Teak
3.	2015-16	Teak
4.	2016-17	Teak
5.	2017-18	Teak

6.	2018-19	Teak
7.	2022-23	Mahagony

Table2: Average Per tree carbon sequestration potential of different age teak plantation

S. No.	Year of plantation	Volume (m^3)	AGB (kg/ tree)	BGB (kg/ tree)	Total biomass (kg/tree)	Carbon (kg/tree)	CO_2 (kg/ tree)
Teak							
1.	2012-13	0.105	62.405	16.226	78.637	39.319	144.302
2.	2014-15	0.058	34.748	9.035	43.783	21.89	80.339
3.	2015-16	0.073	33.237	8.642	41.876	20.94	76.846
4.	2016-17	0.05	29.789	7.746	37.536	18.769	68.878
5.	2017-18	0.04	27.02	7.03	34.06	17.03	62.50
6.	2018-19	0.04	22.59	5.87	28.46	14.23	52.23
Mahagony (2022-23)							
7.	2022-23	0.003	1.852	0.482	2.334	1.167	4.283

Table 3: Organic carbon (%) of different age Teak and Mahagony plantation

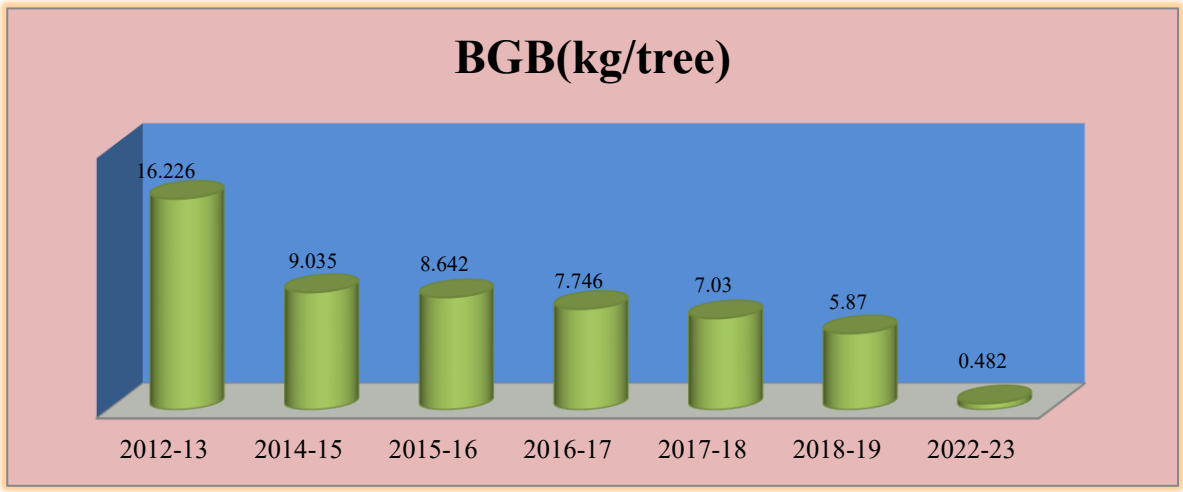
S. No	Year of plantation	Plantation name	Soil organic carbon % (0-15 cm)	(15-30 cm)%	(30-45 cm)%
1.	2012-13	Teak	0.54	0.30	0.23
2.	2014-15	Teak	0.69	0.54	0.37
3.	2015-16	Teak	0.72	0.51	0.36
4.	2016-17	Teak	0.68	0.47	0.23
5.	2017-18	Teak	0.95	0.75	0.50
6.	2018-19	Teak	1.28	1.03	0.53
7.	2022-23	Mahogany	0.31	0.13	0.07

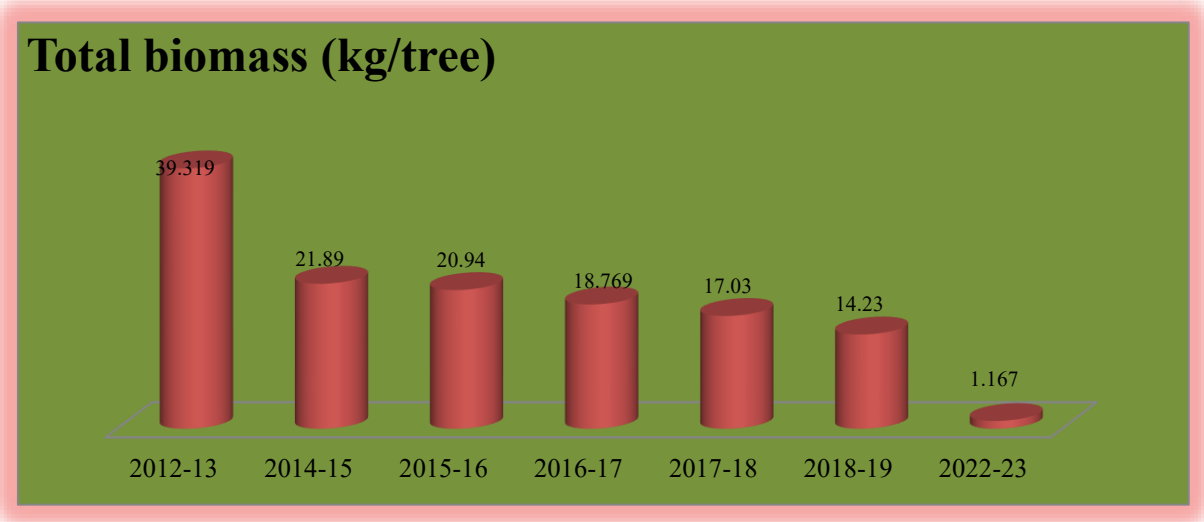
References

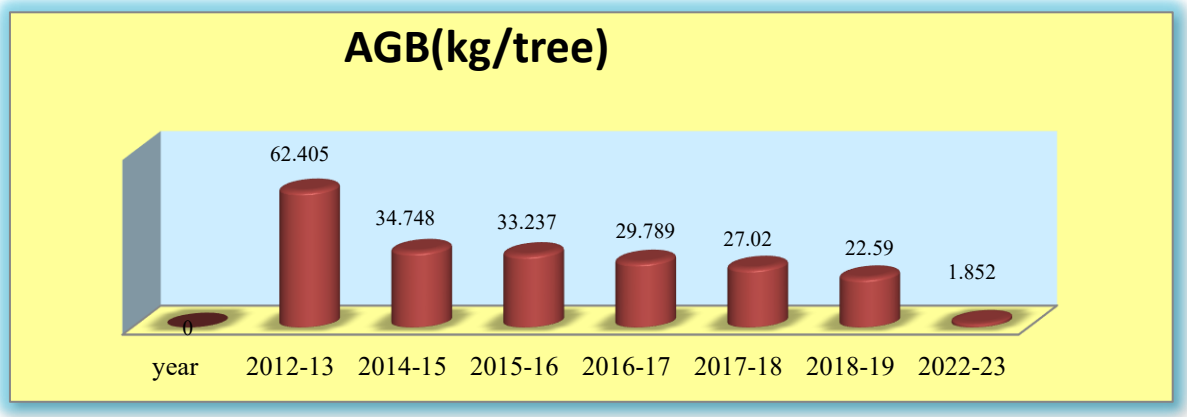
1. Ravi, R., Buvaneswaran, C., Saravanan, S., &Jayaraj, R. S. C. (2012).Carbon sequestration potential of Casuarina equisetifolia plantations at harvest age in three agroclimatic zones under three soil types in coastal region of Tamil Nadu. In *Jayaraj RSC, Rekha R. Warrier, Nicodemus A, Krishna Kumar N, Advances in Casuarina Research in India-Proceedings of the 2nd National Seminar on Casuarinas (eds)* (pp. 345-354).

2. Suryawanshi, M. N., Patel, A. R., Kale, T. S., &Patil, P. R. (2014).Carbon sequestration potential of tree species in the environment of North Maharashtra University Campus, Jalgaon (MS) India. *Bioscience Discovery*, *5*(2), 175-179.

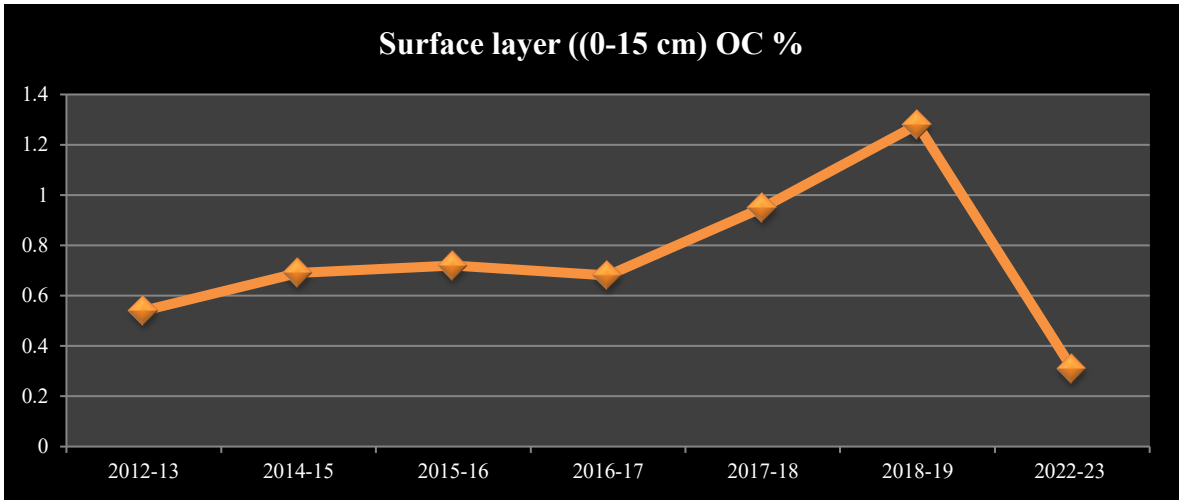
Growth parameters and carbon sequestration potential of different age Teak and Mahogany plantations

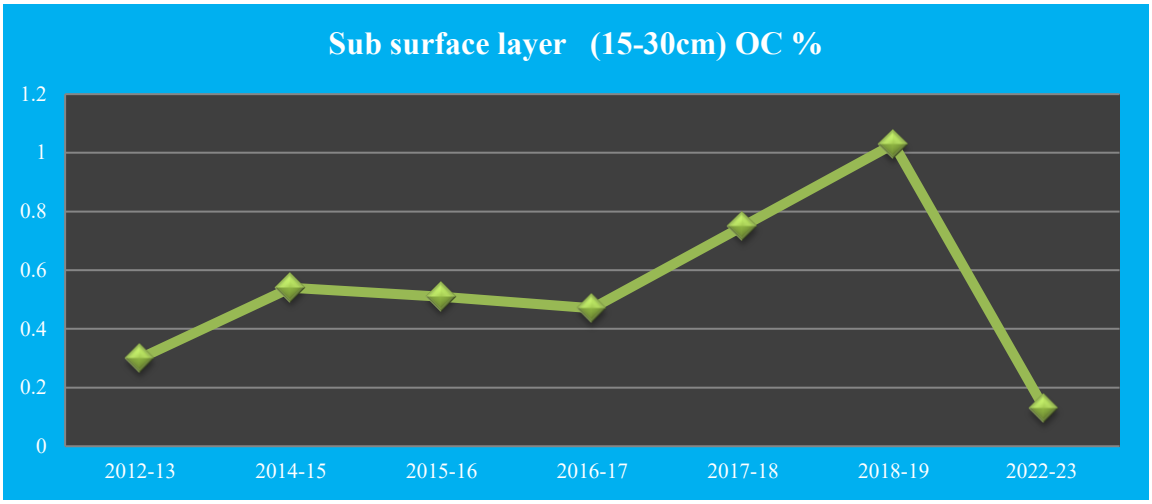


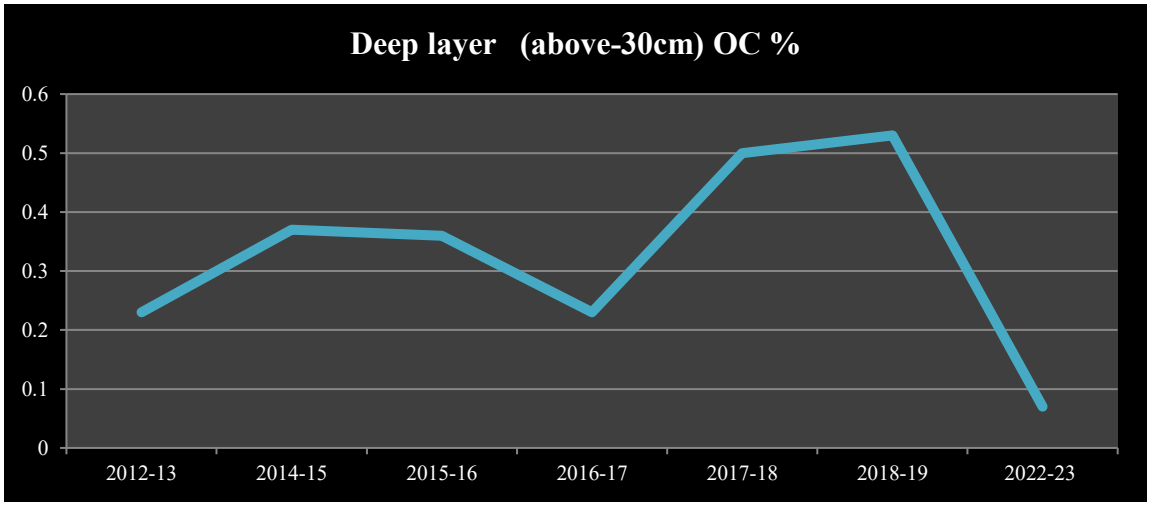




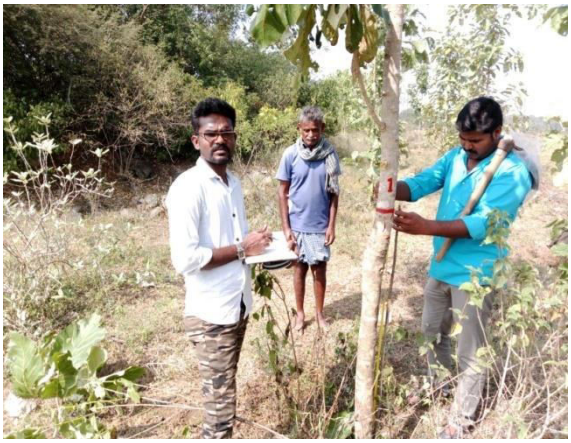
Soil organic carbon potential of different age of teak and Mahogany plantations



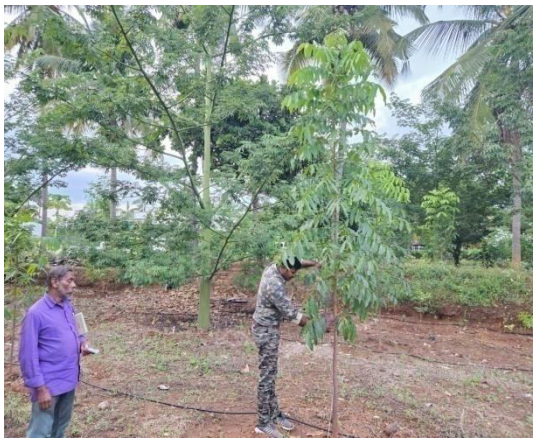




Morphological data collection– Teak Plantation



Morphological data collection – Mahogany plantation



Carbon Sequestration - Teak field inspection