# Carbon stock and carbon credit of *Tectona grandis* plantation in Konkan region of Maharashtra

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## ABSTRACT

A survey-based study on carbon stock, carbon assimilation and carbon credit of teak plantation was conducted on existing teak plantation of Dr Balasaheb Sawant Konkan Agriculture University, Dapoli, dist Ratnagiri, Maharashtra during 2020-21. The growth data of 318 teak trees from experimental plot were collected and carbon in trees was quantified by non-destructive method using allometric equation. The average girth at breast height (GBH) of trees was recorded 21.03 cm and height 10.13 m under the plantation. Carbon stock of 6 years-old age plantation was found 15.60 tonnes/ha and $CO_2$ assimilation or offset by biomass 57.25 tonnes/ha. It was concluded that the carbon sequestration potential of teak and its growth within 6 years was optimum at Konkan coastal zone.

**Keywords:** Carbon stock; teak; carbon credit; economics; plantation

## INTRODUCTION

Teak (*Tectona grandis*) is an economically important tree species belonging to family Verbenaceae and indigenous to India and southeast Asian region. Natural teak forests and plantations are found in the state of Madhya Pradesh, Maharashtra, Tamil Nadu, Karnataka, Kerala, Gujarat, Orissa, Andhra Pradesh, Rajasthan and Manipur (Awasthi 2020). The durability and workability of teak were recognized in our country due to its widespread distribution and cultivation throughout the tropics. Teak constitutes about 75 per cent of the world's high quality tropical hardwood plantation (Reddy et al 2014). It is commonly recommended for plantation programmes in dry tropical regions for timber production. About 44 per cent of the global teak plantations are found in India (Ball et al 1999). Of the estimated 142 million hectares of global plantations in 2005, about 5.82 million hectares (4%) were teak plantations (Reddy et al 2014). Teak has the highest capacity for carbon sequestration among trees in India (Kaushik 2016). Today many countries and private companies are investing in commercial teak plantations however there is a strong concern on global climate change especially after the Paris 2015 Climate Change Conference which raised the interest in planted forests as providers of environmental services eg carbon sequestration. It is appealing for the forest managers to consider the additional potential benefits of producing teak timber and simultaneously providing environmental services such as C storage (Quintero-Mendez and Jerez-Rico 2019). Increasing carbon emission is the major concern nowadays and to minimize the carbon emissions through sequestering more carbon in farm forestry is one way to mitigate climate change and achieve the global targets of reducing the emission intensity of its gross domestic product (Kumar et al 2020). Government of India has set a target to minimise emissions up to 33-35 per cent from 2005 level and to create an additional carbon sink of 2.5-3.0 billion tonnes of carbon dioxide ($CO_2$) equivalent through additional forest and tree cover by 2030 under Intended Nationally Determined Contribution (INDC) submitted to United Nations Framework Conservation on Climate Change (UNFCCC). Tree biomass plays crucial role in global climate change caused by the rising atmospheric carbonic acid gas concentrations because trees store

around 50 per cent of carbon in their dry biomass (Anon 2007). The major objective of raising tree plantations is to promote eco-friendly environment through ecosystem interactions, species diversity and improvement in soil characteristics (Mhaiske and Jain 2019a). Generation of data on potential of different tree species for carbon sequestration in different regions is essential (Kumar et al 2020). Quantification of carbon in trees helps in screening suitable species for raising plantations and their better management (Mhaiske and Jain 2019b). An attempt has been made to assess carbon stock, carbon offset and carbon credit of teak plantation raised at Dr Balasaheb Sawant Konkan Agriculture University, Dapoli, district Ratnagiri, Maharashtra.

## MATERIAL and METHODS

The study was undertaken to determine biomass, carbon stock, carbon offset and carbon credit of teak plantation raised at the experimental site of All India Coordinated Research Project (AICRP) on Agroforestry located at Central Experimental Station, Wakawali, Dr Balasaheb Sawant Konkan Agriculture University. The study site, Wakawali is situated in the Konkan region of west coast of Maharashtra and is a part of Western Ghats. This region is characterised by humid climate with average annual rainfall of 3,500 mm and temperature ranging from 7.5to 38.5°C. The study sites have lateritic soil with altitude of 162 m amsl and are located in the sub-tropical region at 17°43'36'' North latitude and 73°17'50'' East longitude. Teak plantation was raised at study sites in the year 2014 at a spacing of 2.5 m x 2.5 m. Total 318 teak trees were found in the plantation and all trees were considered for the present investigations. All the trees were marked at 1.37 m height from the ground using 1.37 m measuring stick. Growth characteristics of trees from the teak plantation viz height and girth at breast height (GBH) were measured by Ravi altimeter and measuring tape respectively. The above ground biomass of teak trees was quantified by non-destructive method using allometric equations developed by Anon (2017). Following equation was used to estimate above ground biomass in teak trees:

$$y = 0.0248x^2 - 0.1887x$$

where y= Above ground biomass in kg, x= GBH in cm

The below ground biomass (BGB) of experimental trees was calculated using 0.25x times above ground biomass as per norm of Intergovernmental Panel on Climate Change (Anon 1997). The carbon content was considered 0.5x time total dry biomass of trees as per the guidelines of IPCC (Anon 1997). The estimated carbon stocks were converted into $CO_2$ equivalents (quantity of Cx 44/12 or 3.67) for calculating $CO_2$ assimilation by biomass of teak trees in plantation. The carbon credit or certified emission reduction (CER) is the unit related to reduction of 1 tonne of $CO_2$ emission. The value of one carbon credit or CER in US dollar is about $ 17.7 (Kumar et al 2020). All the trees found in plantation were grouped into six GBH classes viz up to 15, 15-20, 20-25, 25-30, 30-35 cm and more than 35 cm class and the data collected were analysed using appropriate statistical methods.

## RESULTS and DISCUSSION

### Distribution of trees under different girth classes

In present investigations, total number of trees of teak was 318 with average GBH 21.03 cm and average height 10.13 m. Maximum trees (128) were reported under 20-25 cm girth class and minimum (6) in more than 35 cm girth class (Table 1).

### Biomass and carbon

Above ground biomass (AGB) of teak was calculated to be 24.96 tonnes/ha whereas below ground biomass (BGB) 6.24 tonnes/ha and total biomass (TB) was found to be 31.20 tonnes/ha. Maximum biomass was found in 20-25 cm girth class (66.25 tonnes/ha) and minimum in girth class up to 15 cm (3.88 tonnes/ha). Range of the carbon stock of teak trees was found between 1.94 and 33.12 tonnes/ha (Table 2). Average carbon content in 6 years old teak plantation was recorded as 15.60 tonnes/ha however per tree carbon content was found to be 0.05 tonnes/ha. Biomass and carbon under girth classes might have differed due to the number of individuals of teak trees present in girth class.

Carbon sequestration in teak trees was comparatively low in younger trees which progressively increased with age. Age of the plantation is most important factor for carbon content in trees (Mhaiske and Jain 2019a). The finding on carbon stock (tonnes/ha) in teak trees is supported by the results of Jha (2015) and Olayode et al (2015). However in the present study more carbon content was reported than observed by Bohre et al (2013), Suryawanshi et al (2014),

Table 1. GBH and height of teak trees

| Girth class (cm) | Total number of trees | Average GBH (cm) | Average height (m) |
|---|---|---|---|
| Up to 15 | 55 | 11.02 | 7.85 |
| 15-20 | 45 | 17.01 | 8.40 |
| 20-25 | 128 | 21.11 | 10.46 |
| 25-30 | 49 | 26.37 | 11.55 |
| 30-35 | 35 | 31.02 | 12.22 |
| >35 | 6 | 39.68 | 13.51 |
| Average | | 21.03 | 10.13 |

Table 2. Biomass, carbon stock, carbon offset, carbon credit and carbon value of teak plantation

| Girth class (cm) | Total biomass (tonnes/ha) | Carbon stock (tonnes/ha) | Carbon offset (tonnes/ha) | CER or carbon credit | Economic value ($) |
|---|---|---|---|---|---|
| Up to 15 | 3.88 | 1.94 | 7.12 | 7.12 | 126.06 |
| 15-20 | 13.11 | 6.56 | 24.06 | 24.06 | 425.83 |
| 20-25 | 66.25 | 33.12 | 121.57 | 121.57 | 2,151.74 |
| 25-30 | 43.99 | 21.99 | 80.71 | 80.71 | 1,428.65 |
| 30-35 | 46.09 | 23.04 | 84.57 | 84.57 | 1,496.84 |
| >35 | 13.88 | 6.94 | 25.47 | 25.47 | 450.86 |
| Mean | 31.20 | 15.60 | 57.25 | 57.25 | 1,013.33 |

Oo et al (2007) and Behera and Mohapatra (2015) and less than as observed by Sreejesh et al (2013), Reddy et al (2014) and Giri et al (2014).

Overall average $CO_2$ assimilation or offset by biomass of teak trees in plantation was calculated as 57.25 tonnes/ha with minimum value of 7.12 tonnes/ha under girth class up to 15 cm and maximum 121.57 tonnes/ha under 20-25 cm girth class. $CO_2$ assimilation value reported under this study is in accordance with the findings of Selvaraj et al (2016) and Kongmeesup and Boonyanuphap (2019).

The carbon credit or certified emission reduction (CER) is the unit related to reduction of 1 tonne of $CO_2$ emission. The value of one carbon credit or CER in US dollar is about $ 17.7. Accordingly the total value of 57.25 carbon credit or CER in US dollar was about $ 1,013.33.

**Per tree biomass and carbon content**

Per tree biomass and carbon were estimated and the data are shown in Table 3. It was found that the maximum biomass and carbon content were under the girth class more than 35 cm followed by 30-35, 25-30, 20-25 and 15-20 cm and minimum in up to 15 cm girth class. Average carbon content in studied plot was found 50.51 kg per tree.

## CONCLUSION

Teak-based farm forestry system is one of the important elements of terrestrial ecosystem that provides direct benefits like timber and non-timber forest products and numerous indirect benefits like biodiversity conservation, protection of watersheds, habitat for wildlife, tourism, maintenance of ecological balance, control of soil erosion and various other ecosystem services. Accumulation of biomass in teak trees under farm forestry system, resulting in carbon stock, carbon sequestration and certified emission reduction are major environmental goals to reduce the emissions in developing countries. Present study concluded that the impacts of greenhouse gases, global warming and climate change can be reduced or improved through plantation of making farm forestry production systems more profitable as well. In general trees also provide numerous intangible benefits and the economic valuation for their carbon credit enhances their value which helps in managing them in more sustainable manner.

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Table 3. Per tree biomass and carbon content in experimental plot

| Girth class (cm) | Total number of trees | Average biomass and carbon (kg/tree) | | | |
|---|---|---|---|---|---|
| | | Above ground biomass | Below ground biomass | Total biomass | Carbon |
| Up to 15 | 55 | 9.69 | 2.42 | 12.11 | 6.06 |
| 15-20 | 45 | 40.00 | 10.00 | 50.00 | 25.00 |
| 20-25 | 128 | 71.05 | 17.76 | 88.81 | 44.41 |
| 25-30 | 49 | 123.24 | 30.81 | 154.05 | 77.03 |
| 30-35 | 35 | 180.75 | 45.19 | 225.94 | 112.97 |
| >35 | 6 | 317.61 | 79.40 | 397.01 | 198.51 |
| Mean | | 80.81 | 20.20 | 101.01 | 50.51 |

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