May 2016

An assessment to understand the ecological requirements and management strategy for enhancement of growth and quality of teak plantations in Tiruvannamalai District, Tamil Nadu

KEYSTONE FOUNDATION

An assessment to understand the ecological requirements and management strategy for enhancement of growth and quality of teak plantations in Tiruvannamalai District, Tamil Nadu

FINAL REPORT

Prepared for

Apollo Tyres Foundation
Gurgaon, India

By

Keystone Foundation

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1. Introduction

Apollo Tyres Foundation (ATF) TF engaged Keystone foundation (KF) to conduct an assessment to understand the ecological requirements and management strategy for enhancement of growth and quality of teak plantations in Tiruvannamalai District, Tamil Nadu. ATF is sponsoring farmers growing trees species as credit to carbon sinks. The study focuses on the health status of the teal trees in the villages sponsored by Apollo Tyres Limited.

2. Objectives

- To understand the history of teak plantation in the study sites
- To understand the ecological requirements for teak plantation and growth of teak trees
- To investigate the disease, insect and pest infestation in teak plantation
- To suggest /recommend suitable management practices

3. Description of study site

The study was conducted in Vandavasi of Tiruvannamalai district of Tamil Nadu. It is located at 12.5°N 79.62°E. It lies 110 kilometres South-West of Chennai City, South of famous temple city Kanchipuram and 80 km north-east of Tiruvannamalai. It has an average elevation of 74 metres. It has a hot and humid climate. Physiographically, is it formed on undulating terrain dotted with clusters of hillocks. The predominant soil type is red. Red loam / Red sand were also found. Tanks and dug-wells were the major sources of irrigation. Agriculture is the main occupation, Paddy, sugarcane and groundnut was the major crops grown. Coconut, Mango, Borassus plam is grown along the earthen bunds of the agriculture fields.

The region receives northeast and southwest monsoon. For the past ten years, there has been an erratic rainfall pattern in this region. Hence, due to scarcity of water the farmers were not able to cultivate paddy in these many years. The farmers have now planted trees of timber value such as Teak, Thespesia, Dalbergia and Mahogany in the lands that are fallow.

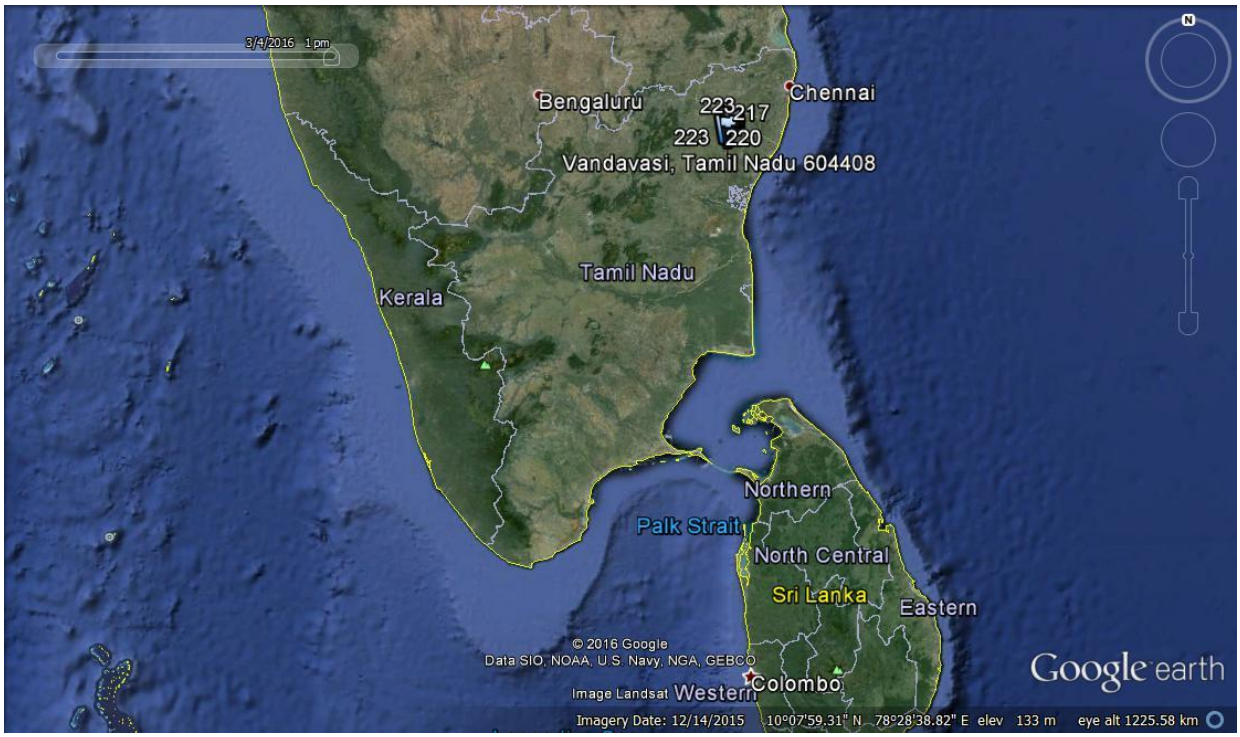

Image 1: Location of study site

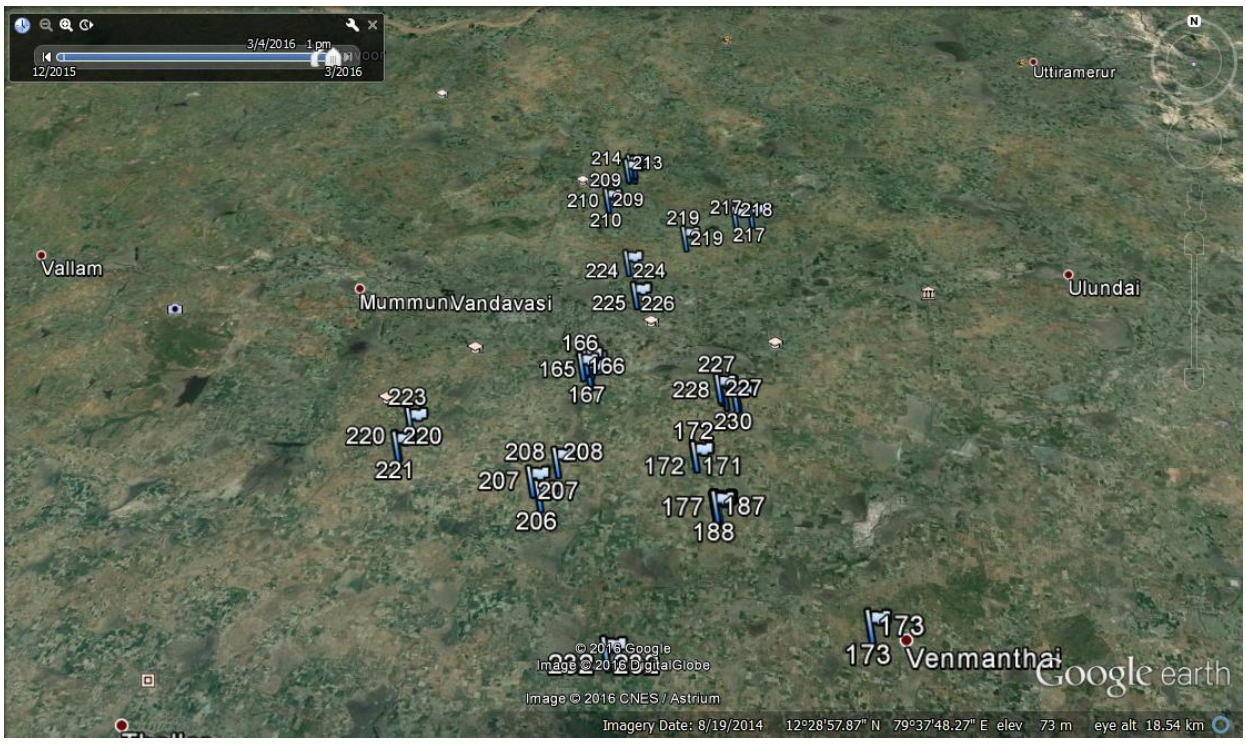

Image 2: Villages visited in the study site

4. About Teak – *Tectona grandis L.*

- Teak is a deciduous tree, medium to large sized tree (30-35m). The trunk is generally straight and branchless in the lower part.

- The species is a member of the family "Verbenaceae". The natural distribution of teak is limited to the Southeast Asian region.

- The species occurs naturally only in the Indian Peninsular, Burma, Northern Thailand and North-western Laos along the northern Thai border.

- Soil requirements: Teak can grow in a variety of soils; however, it depends on the drainage and water holding capacity of the soil.

- Soil moisture: Teak occurs naturally over a wide range of climatic conditions, from very dry localities with annual rainfall as low as 500 mm to very moist localities with annual rainfall as high as 5,000 mm. For the production of good timber qualities the species requires a periodic marked dry period of 3-5 months. Teak appears to avoid both very dry and very moist sites. On dry sites where severe drought stress occurs in the hot-dry season, teak is found to be stunted and shrubby probably due to reduced growth and early loss of apical control. On very moist sites, tree is usually large and fluted.

- KAOSA-ARD (1977) reported that teak required a relatively high soil moisture conditions for its growth and development. The seedlings of this species when grown under the high constant soil moisture (near the saturating point) for eight weeks were about five times greater, in term of dry matter production, than those grown under the severe soil moisture stress.

- Temperature: Naturally, teak occurs over a wide range of climatic conditions, varying from one locality where the maximum temperature may be as high as 48·c for the hottest month to a locality where the minimum temperature may be as low as 2'C for the coldest month. Under frost conditions, seedlings, saplings and even the pole-size trees of this species are severely damaged, especially at the succulent parts such as terminal buds and shoots, young leaves and bark cambium, leading to die-back.

- Light: Several studies indicated that teak is a light demanding tree species; in other word this species is intolerant of shade.

5. Methodology

The assessment was done in the month of March. Visual observations were made in the various plots of teak being grown in the various villages around Vandavasi. All the plants were between 1-2 years of age. The villages visited were Sedarakuppam, Muzhuvangarai, Venmanthai, Salukai, Karam, Aariyathur, Hosur, Thazhuthalai, Yeripattu, Thamarakakkam, Nellari, Maruthuvambadi, Biruthur, Manganallur, Maruthadu, Narashingapuram, Nallur, Muthalur, Kilvillivanam

To understand the health status and disease infestations in the teak plantations as follows:

- **Field observation:** Observation were recorded the health status and disease infection by noting the deficiency symptoms of the leaves and growth performance. A data sheet was prepared for the same. (Annuxure1: Data sheet)
- **For Deficiency symptoms:** the following observations were made
  - Yellowish colour leaves was noted
  - Yellowish/drying of leaf margins and leaf tips
  - Leaf rolling
  - Rusty patches
  - Necrosis
  - Intervenial chlorosis
  - Chlorosis in older leaves
  - Premature leaf fall
  - Multistems
- **Focus group discussion:** An informal group discussion was conducted with the farmers to understand the farmers to understand the history and land use practices in the villages. It recorded the health status and disease infection observed by them in the past few years. Management practices was also discussed.

- **Soil testing:** The soil samples were collected to test for pH, electrical conductivity, Nitrogen, Potassium, Phosphorous, Sodium, Boron, Zinc, Manganese, Iron, Copper, Calcium (macro and micronutrients), to

understand the deficiency symptoms of macro and micronutrients and pathogens present in soil. The soils were randomly collected from 2-3 point of the field. The number of soil sampling was also based on the soil types observed in the teak plantations. Moreover, in certain cases soil samples were taken from field that that had intercropping in the teak plantation. The soil samples were given to a laboratory to conduct the nutrient analysis.

- Observation for disease/pest infestation: Visual observations were made in the various plots of teak being grown in the various villages to understand insect and pest infestations.

5. Observations

5.1 General observations

All the plants were between 1-2 years of age in the villages visited. The farmers had initially cultivated paddy and groundnuts and as there was shortage of water to irrigate the fields, they decided to plant teak trees. The saplings were planted with a spacing of 8*8/10*10/12*12 ft and thinning done once. The trees were 4m of height with an average girth at breast height (GBH) of 14-20cms. The young trees had uneven growth within the same age of planting. Few trees were at a height of 4ms. The leaves were yellowish with drying margins and leaf tips. Black rusty patches were observed in the leaves. The leaves had infestation with skeletoniser and defoliators, which is minimum. Few sap feeders was observed on the leaves. Few farmers had maintained the teak plot by thinning and irrigating the fields. There was intercropping of vegetable and flowering crops in the teak fields. It was observed that the fields that had intercropping was irrigated at time intervals and supplemented with manure and the young teak trees looked healthy. Crops like tomatoes, brinjal, ladies finder, bitter guard, radish, chrysanthemum and chillies were cultivated as intercrops. Wilting was observed in few teaks which causes death of the tree.

Image 3: Intercropping in teak plantation

The farmers had switched to teak plantation due to scarcity of water. Teak trees less usage of water when compared to paddy cultivation. For the past 10 years, the region receives erratic rainfall and facing prone. The heavy rains in 2015 have caused water logging causing damages to the trees and ultimately death of the trees. The farmers say that the drying / wilting and pests in the trees are a prevalent condition during the summer season.

The International Small group Tree Planting group (TIST) provided the saplings to the farmers. They had identified farmers interested in teak farming through various meetings conducted in the village. Training on teak planting and management practices were given by TIST. As the quality and source of the sapling purchased was needed to be observed, details' regarding the same was not available from the staff of TIST who had accompanied us during the visits made. It was observed that the farmers needed more intensive training on management practices and observing the growth performance.

5.2 Soil characteristics

- **Soil profile:** The relative proportion of sand, silt and clay separates determines soil texture and it is an important property of soil. Different types of soil were observed in the teak plantations. Given below are the different types of soil observed in the fields sites

Village	Soil type
Saetharakuppam	Loamy/reddish brown
Muzhuvangarai	Red soil
Venmanthai	Red soil
Hosur	Granular/ red
Kil villivanam	Loamy/red Granular '*Kallan cheradu*'
Salukai	Red/granular
Kaaram	Loamy/Red *'Senkkatu mannu'*
Ariyathur	Red
Yeripattu	Red/Gravelly *'Manalpangu'*
Thamaripakkam	Red soil Clayey soil *'Kalimannu'*
Nellarai	Granular/red soil
Maruthavampadi	Red soil
Biruthur	Clayey
Manganallur	Clayey
Maruthadu	Loamy/Red/Granular *'Karisal mannu'*
Narashingapuram	Loamy
Nallur	Clayey
Muthalur	Clayey

- Red soils are red in colour is red due to their very high iron content. Red Soil in India is poor in phosphorus, nitrogen and lime contents. Usually sugarcane and pulses are grown on red soil. Loam is ideal for gardening and agricultural uses because it retains nutrients well and retains water while still allowing excess water to drain away.
- It was observed that the teak sapling planting in the clayey soil were rotten and dead (Manganallur, Nallur, Maruthadu, Thamarapakam plots). Teak needs well-drained soil for it growth as clayey soil retains water it does not support the growth of teak. Similar observations were made in plots with streams flowing nearby.
- It is suggested that planting can be avoided in clayey soil types. Loamy –red soil types can be preferred for planting teak sapling.

- 43 soil samples were collected from the study sites. The following parameters were tested for the soil samples collected from the teak plantations. The minimum and maximum values is given below

Parameters	Values (range)
pH	6.08- 8.03
Electrical conductivity	0.40-1.05 mS/cm
Calcium	0.43-2.12 %
Nitrogen	0.27%-0.40%
Phosphorous	412- 607ppm
Potassium	0.154 - 0.859 %
Boron	Bdl- 27 – 79 µg/g
Zinc	Bdl- 176- 241µg/g
Manganese	1001-1972µg/g
Iron	0-355-500 ppm
Copper	Bdl- 47- 72µg/g

- pH

- Teak occurred predominantly on soils with pH values ranging from 6.5- 7.5.
- The result shows that most of the soil has a pH value of 8.
- Alkaline soils with pH values ranging from 7.5-8.5, teak deteriorates in qualities, and above a pH level of 8.5 the presence of excess alkalis in soils seemed to be definitely toxic toward teak growth.

- Calcium and mineral in the soil:

- Apart from soil pH, a number of mineral elements content in soil such as Ca, P, K, Mg, N etc. have been found to play an important role in controlling distribution and growth of teak.
- Several studies showed that teak is a "calcicolous" tree species. It requires a relatively large amount of calcium for its growth and development.
- Studies show that the calcium (Ca) requirement ranges from 14-80 %/ha. Soil test results show values less than the required range (0.43-2.12 %). The range for Potassium (K) was estimated at 0-9% the test result shows (0.154 - 0.859 %).
- Despite the commonly high nutrient requirements of the species and the general belief that soils under teak plantations tend to be fertile, the soil tests reveals that most sites exhibit soil deficiencies of some kind, especially related to Ca, K, acidity and P.
- Plantation teak, however, is grown on a variety of soil and site conditions, where P and K deficiency symptoms such as chlorosis, necrosis, and dieback were frequent in the sites observed.
- Stunted growth is also caused by nutrient deficiencies.

- Insects/Pest observed:

- *Defoliators:* The infestation of the defoliator H.puera is considered more frequent than that of the skeletoniser and generally occurs suddenly, mostly after pre-monsoon showers. H.puera caterpillars feed on young foliage during the early part of the growing season (Nair et al., 1996).
- *Skeletoniser:* The second major pest after H.puera, the teak leaf skeletoniser is generally found towards the end of the growing season before the shedding of leaves. Its caterpillars feed on the older leaves eating the leaves leaving the veins intact (Nair et. al., 1996).
- *Leaf rust:* Leaf rust was observed in the 1-2 year old saplings almost in all groves that were visited and this infection could be considered to range from low to moderately high in extent. The condition can be recognized by the clearly visible orange powdery presence of the fungi mainly on the underside of the leaves.
- *Wood dwelling termite:* The swelling of stems and branches is an indicator of infestation by this organism, as this wood-dwelling termite hollows out the above parts. The presence of such termite soil nests above ground were sighted only in a few of the groves and only on a very few trees within those groves.
- *Wilt disease:* The bacterium *Pseudomonas tectonae* causes wilt. This disease usually attacks teak seedlings or young teak trees. Early symptoms are the presence of light and dark brown patches, followed by leaf wilt and leaves turning pale or yellowish. The development of wilt may be gradual or sudden with leaves falling in a short period.

6. Recommendations

- *Soil requirements*

Soil colour	Reddish brown, red, dark brown Yellow grey, like –brown, white soils	Suitable for planting Unsuitable for planting (temporary or permanent water logged conditions)
Planting time .	It is recommended that the planting of teak to be done during the rainy season. Planting of teak stump can be done in the drier periods	
Pruning	De-budding and pruning of side branches	For 2-3 years, First thinning when tree is 9-10m. Second thinning when tree is 17-18m
Weeding	Once a month	
Spacing	4*4m 12*12m	Standard For plot with intercropping.

- *Nutrient recommendations*

Applying fertiliser when the trees reach 1, 2 and 3 years in age is recommended.

	Name of the fertilizer	Dosage	Use
Fertilizers	Diammonium phosphate (DP)	75 or 150kg/ha– N and 50 or 75 kg /ha– P	Significantly increases height growth of teak in the first two years after

			establishment
	Diammonium phosphate (DP)	80-120 gm/plant	Applied in circular ditches 10 cm deep and 20 cm from each plant significantly increases height growth in the first two years after establishment.
	NPK	Fertilizer (50 gm/plant annually for three years)	positive height and girth responses
	Urea Mussoorie rock phosphate, Muriate of potash quicklime and Magnesium sulphate	163kg/ha 375kg/ha 145 kg/ha 105 kg/ha 373 kg/ha	Overall growth of plant
	N, P_2O_5, and K_2O	30 to 40 gm/plant 15 to 20 gm/plant 15 to 20 gm/plant	Per plant per year during 2 to 5 years of plantation age and thereafter once in 3 to 4 years for 10 to 12 years
	Dolomite	150-250 gm/plant hole	Increases calcium level
	Calcium phosphate	50-200gm/plant	Promotes growth
Bio fertilizers	Mycorrhiza fungi		Promotes growth
	Phosphobacteria+AMF (Glomus aggregatum)		Promotes growth
	Azotobacter		Promotes growth

- *Agroforestry*

  - The advantage of an agroforestry system is that farmers gain short-term income from agricultural crops such as maize, peanuts, cassava, and spices, such as turmeric and ginger; medium- to long-term income from timber.
  - Agricultural crops in the Solanaceae family (brinjal, for example) should not be planted when teak is still young because they are hosts for wilt.
  - Land gradation can be practice by which water stagnation can be regulated.

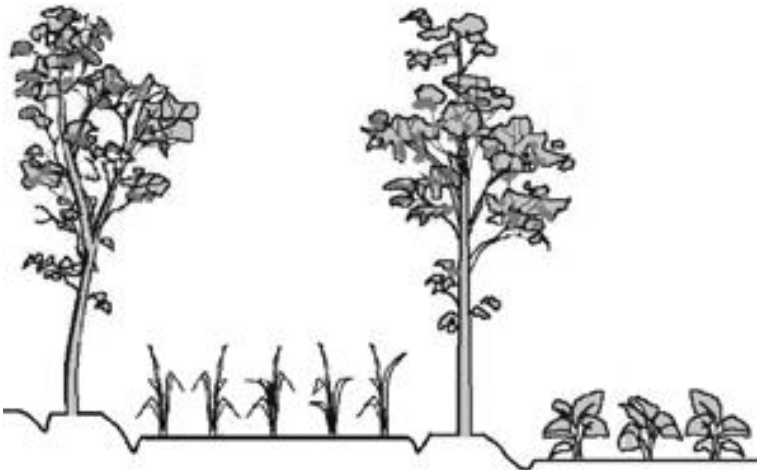

Image 4: Land gradation

Agriculture crops	Maize, turmeric, tomato, chilly, banana, Brinjal, Amaranthus, cotton, pulses
Fruit crops	Guava, Custard apple, Cinnamon, Coconut
Tree crops	Arid/dry region - Sandal wood, White Kashmir teak(*Gmelina arborea), Toona ciliate(Toona)*

- *Pest and Disease*

Pest/Disease	Management
Skeletoniser	• Mixed plantations • Clip severely affected leaves • Spraying of Neem Seed Kernel Extract (NSKE) 5% • Spraying of Quinalphos @ 2 ml/lit
Defloliator	• Clip badly affected leaves with larva • Spraying of Neem Seed Kernel Extract (NSKE) 5% • Setting up of light trap to trap adult moths
Leaf rust	• The infected seedlings can be

	segregated and kept in isolation. • Thinning helps a bit in controlling spread of this fungus. • Severely infected and dead seedlings can be burnt away from the nursery to prevent the spread of the disease. • The disease may be controlled in the nursery by the application of sulphur based fungicide (Sulfax) on both sides of the leaves. • Application of Plantvax (0.0l% a. i.), a systemic fungicide effective against rusts, may also be found effective in controlling teak rust. (Sharma et. al., 1985)
Wood dwelling termite	• Regular thinning • Cut and burn infected parts • Chemical treatment with fumigant insecticides (Phostoxin ¼ tablet) or insecticides containing Fenpropatrin (Meothrin 50 EC) is an option, as of this survey, it is not recommended based on the number of instances of the termites encountered.(Pramono et. al., 2011)
Wilt	• Destroy seedling immediately by burning • Use of bactericide containing streptomycin sulphate, dazomet.
	(Neem azal 1%) - at an interval of 10-12 days, can give good control for pest control.

Image 5: leaves infected by defoliators

Image 6: Leaf rust

Image 7: Neotermes tectonae, a wood-dwelling termite

- *Carbon sequestration*

Carbon sequestration phenomenon is the extraction of the atmospheric carbon dioxide and its storage in terrestrial ecosystems for a very long period of time. Plants store carbon for as long as they live, in terms of the live biomass. Most terrestrial carbon storage is in tree trunks, branches, foliage, and roots which is often called biomass. Trees act as a sink for CO2 by fixing carbon during photosynthesis and storing excess carbon as biomass.

Teak is the most important forest plantation species and it occupies the major area under forest plantations and in addition to its value as an ideal timber, it also plays an important role in storing carbon. It was estimated that 181.13 ton carbon per hectare could be stored by a teak plantation in Kerala during its life time of 50 years by yielding biomass at different stages of thinning operations and at final felling stage.

A Forest ecosystem is reported as a major biological scrubber of atmospheric CO_2. Carbon sequestrations in forests occur in living above ground biomass and living biomass of soil. Generation of planted forest and plantation is an alternate way to stabilise and minimise the atmospheric concentration of carbon. Forest or plantation with mixed species is more efficient in sequestering Carbon than monocultures.

Below mentioned are species recommended for planting with their carbon sequestration value.
Total organic carbon storage in selected native tree species

Species	tC/species
Terminalia arjuna	44.81
Tamarindus indica	55.95
Bombax ceiba	40.76
Madhuca indica	22.15
Azadirachta indica	19.28
Ficus religiosa	16.01
Mangifera indica	15.23
Manilkara elengi	4.64
Syzygium cumini	3.77
Emblica offiicinalis	1.77

Source: Pandya et al., (2013)& Jagiwala J(2015)

7. Reference

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8. Annexures

- Annexure 1: Field notes
- Annexure 2: Brief about teak pests and other associated insects
- Annexure 3: Queries regarding teak
- Annexure 4: Soil testing results