

TEAK TREE INVENTORY AND AUDIT REPORT 2022

CONDUCTED FOR

ASIA TEAK GROUP

AT

Batticaloa Teak Plantation

Sri Lanka

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Forestry inventory team

Executive summary

Batticaloa Teak Plantation which was established during 2012 July to 2013 December is one of the largest Teak plantation among the three estates of Teak plantations namely Batticaloa, Anamaduwa and Puttalam plantations, managed by Asia Teak Tropical Plantation. Mr.J.M.P. Jayalath, Mr.Eranda Rathnamalala and me visited on 2021.3.19 and 20 in order to inventories and audit the tree stocks of the plantation. The annual tree audit and evaluation of tree sample data are conducted independently under globally accepted methodologies which explain in this report. All the sample data were collected throughout audit process under close supervision. I certify that the inspected plantations are presently in reported condition.

DBH measurements of 1581 trees were taken from Batticaloa plantation and 20 sample plots which covers 2.94 ha area were used for forest inventory. It is estimated that total planted area of Batticaloa plantation is 29.5 ha. The total tree number is 15458 in Batticaloa,

Batticaloa Teak Plantation

Twenty sample plots having with total sample area of 29400 m² have been permanently setup in different locations in Batticaloa plantation. It is found by this study that total estimated planted area is 29.5 ha and sample plots represent 9.96 % of population. In this study, 1581 trees were measured for DBH measurement and height measurement of 200 trees were taken by hypsometer. We applied all the international standards when measuring the tree parameters such as DBH and Height. (See page 15-17). There are 15458 trees in this plantation in which 1581 trees measured for DBH which represent 10 % of population.

This inventory results show that there are 15458 trees (13503 good trees, 1717 small and 238 reserved tree). The average DBH and Height of trees in the estate is 12.7 cm and 10.5 m respectively. It is found that average trees per ha is 546. In 2021 tree count audit, out of 15774 total trees, there were 13286 good trees, 2250 small and poor trees, and 238 reserved trees. In 2022 audit it is found that there are 316 trees less than from total tree number of 2021 audit which may be thinned out or uprooted/dyeing. Details of block wise tree information are shown in table 3.3 and (3.4).

Analyzing inventory tree data, it is found that more than 29% of trees are having DBH more than 14 cm for Batticaloa plantation that means, out of 15458 trees. There are 4556 trees having more than 14cm DBH. Block wise results are given in graphs, see page, 18-22. The descending order of mean DBH values of Block 1, Block 3, Block 2, Block 4 and Block 5 are given 14.3cm, 12.7cm, 12.4cm, 12.2cm, and 11.7cm respectively. According to table 3.4.1-3.4.5. Current Annual Increment results show that Block 3 and 4 have better growth

compared with other blocks during the last year. These findings can be used for future planning of thinning and final mode of harvest.

After analyzing the last 10 years of growth and DBH data of 2015-2022, Mean annual increment of DBH and Height is 1.27 cm and 1.08 m respectively. It was observed that tree height growth has performed much better rate compared with past. This site growth parameters can be used to find the comply site quality (Yield class) or prepare the own yield table.

In order to estimate the timber volume of plantation, mid diameter and DBH values of several trees were taken as sample to determine the form factor and actual volume of tree. This finding is that tree form factor is around 0.45. Total tree volume of each block was estimated based on mean DBH, Mean Height and Form factor. The Descending order of mean volume per tree of Block 1, block 3, block 4, bock 2 and block 5 were found as 0.091 m³, 0.06 m³, 0.055 m³, 0,054 m³ and 0.044m³ respectively. Mean tree volume for Batticaloa site is around 0.06. The mean tree volume for ha is 33.5 m³. Furthermore it is estimated that this plantation contains of 885 m³ of timber. Our great task should be either we reduce number of trees per ha in order to produce larger trees or maintain optimum number of trees to get as much as possible (maximum) timber volume. We have to study what is the maximum number of trees per ha that can produce larger stem diameter and height (volume). In order to do that we will have to prepare the best thinning regime for this plantation .The yield table that is going to be built will solve this question. All this activity to be performed we need to decide the final composition of yield (log size, No. of trees per ha)and its value too.

1. Introduction

1.1.General Introduction of Teak (*Tectona grandis*) Plantation.

Teak (*Tectonagrandis* L.f.) is a highly valuable timber in International trade sought by wood industries to produce good quality furniture and wood for house construction, carving, shipbuilding and many other purposes and Teak is an important timber species for tropical forestry, Today teak is a profitable plantation crop promoted by government agencies, the private sector and farmers. Teak plantations are widely established across Indonesia, Thailand, Sri Lanka etc. in some places, they have become an inseparable part of local cultural and socioeconomic systems.

Bole form

Fluting (irregular involutions and swellings) in the teak stem has been observed in a number of plantations in tropical countries. In some study, the mean heritability value of

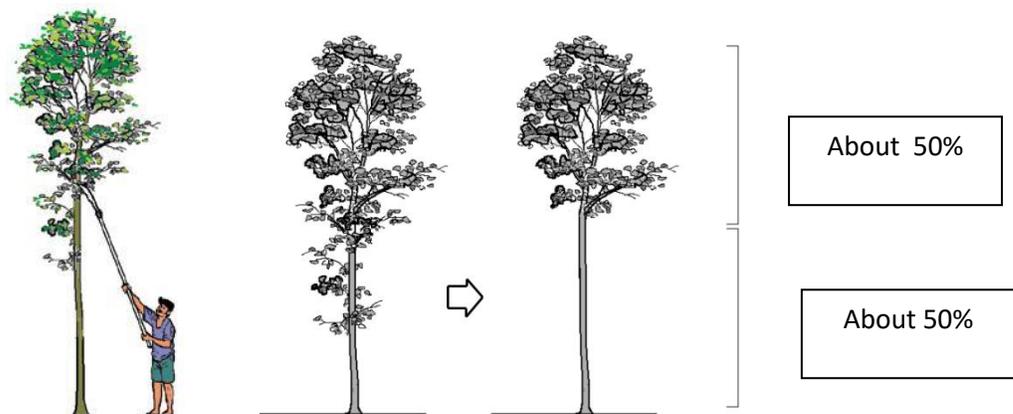
stem straightness was found to be 0.83, indicating that the character for stem straightness is strongly controlled by provenance and is thus genetically inherited (Kaosa-ard, 1999). Hence, fluting can be minimized if the appropriate provenance is used in breeding trials to produce plants that exhibit straight stems. The most important form characteristic determining the value of teak logs is the length of the clear bole.

1.2. Activities of teak stand maintenance

Teak grows well, grows fast, and produces high-quality timber when the land and trees are well maintained. Maintenance includes weeding, fertilizing, replanting, pruning, thinning, maintaining coppices and controlling pests and diseases.

1.2.1. Pruning

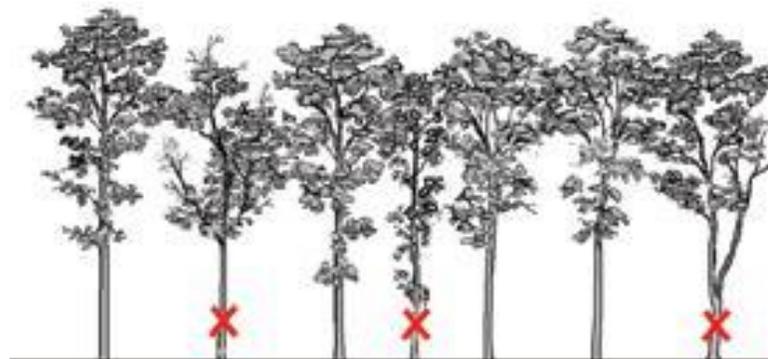
pruning is the removal of branches which increases clear bole height and reduces knots on the main stem



Recommended height to which branches should be pruned

1.2.2. Thinning

By competition for light, water and nutrients is greater in closely spaced plantations causing slower tree growth and tall, skinny stems. Thinning will encourage better growth for the good quality trees that remain.



1.3. Spacing

The spacing of trees and the number, timing and intensity of thinning strongly affect the pattern of growth and the yield of the plantation. If thinning is practiced late, growth rates decline or cease, whereas if the stand is thinned too early or too heavily, the trees have a greater tendency to produce side branches and epicormic shoots. This also reduces the potential yield of the plantation since growth is diverted from the main stem, which should be free from defects such as those caused by side branches and epicormic shoots.

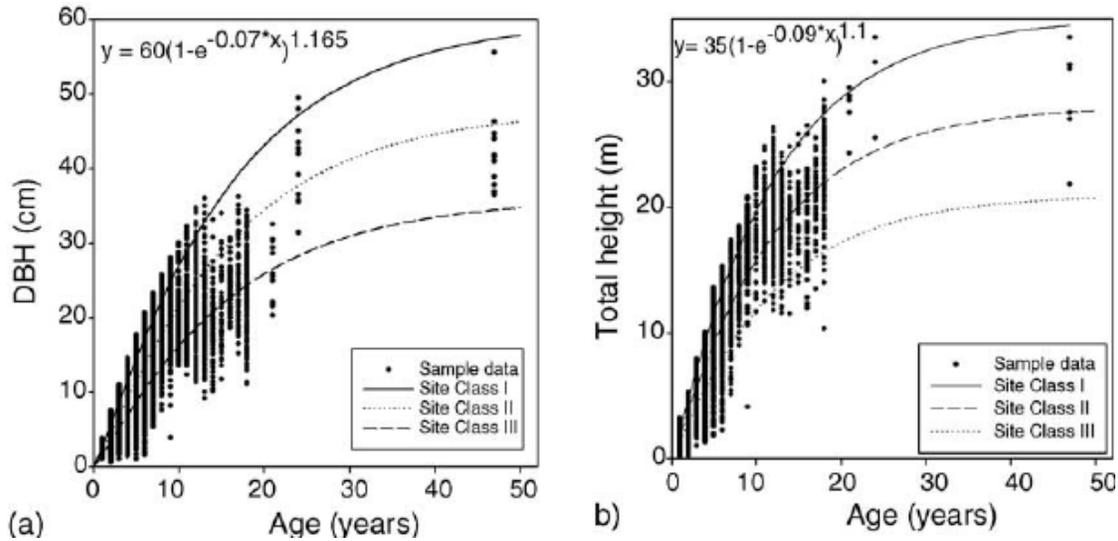
Table A: Trees left after thinning based on tree height

Tree height / (m)	Trees remaining / (trees/ha)	Age (yr) / (range based on soil fertility)	Spacing / (m)
11.0–13.0	1300–1500	5–11	2.5–3.0
13.5–15.5	1000–1100	7–17	3.0
15.5–17.0	800–850	10–21	3.5
17.5–21.0	500–550	15–34	4.0–4.5

1.3.1. Teak growth parameters

Height (H) and diameter at breast height (dbh) are the most important measures of tree growth and their relationship is useful in determining site-index, calculating tree volume, evaluating site -quality and predicting future growth of the stand (Jayaraman and Zakrzewski,2001).

Following growth information published by researchers can be used to develop the yield prediction table for present teak plantation of Asia Teak group. Three Yield tables are being prepared for Batticaloa , Anamaduwa and Puttalam teak plantation.



(a) Teak growth curve: DBH against age

(b) Teak growth curve: Total height against age

Table 1. Growth parameters of Teak governed by site quality of some other countries

Site quality 19							
Age	No. of stems/ha	Top height(m)	DBH(cm)	Per Tree volume (m3)	Trees volume /ha	MAI (m3/ha/year)	CIA (m3/ha/year)
3	1111	8	6.9	-	-	-	9.9
5	776	13.4	13.1	0.03	27.2	5.4	13.6
8	542	17.6	18.6	0.102	55.3	7.6	11.3
12	379	19.3	22.2	0.259	98.5	9.7	13.7
20	265	21.3	27.0	0.449	119.0	7.9	5.2
25	185	21.7	31.5	0.62	115.3	7.1	4.3

Table 1.1. Growth parameters of Teak governed by site quality of some other countries

Site quality 21							
Age	No. of stems/ha	Top height(m)	DBH(cm)	Per Tree volume (m3)	Trees volume m3/ha	MAI(m3/ha/year)	CIA(m3/ha/year)
3	1111	8.3	7.2	0	0	0	11.3
5	754	14.4	14.2	0.04	30.2	6	15.1
8	512	19.3	20.5	0.15	76.8	10.4	17.8
12	347	22.1	25.5	0.310	107.6	11	12
20	236	23.9	30.7	0.619	146.3	9.7	7.8
25	160	24.3	36.1	0.85	136	8.7	4.5

Teak Tree Inventory Audit Report – Batticaloa Plantation

Age (years)	H_0	Main crop before thinning					Crop removed					Main crop after thinning					Total crop		
		N	D_g	G	V	Hart	N	D_g	G	V	Vt	N	D_g	G	V	Hart	VT	MAI	CAI
Quality 23																			
3	8.6	1111	7.5	4.9	0	34.9	399	0	0	0	0	712	9.4	4.9	0	43.6	0	0	0
5	15.3	712	15.2	13.0	49.8	24.5	256	12.1	2.9	12.5	12.5	456	16.8	10.1	37.3	30.6	49.8	9.9	24.9
8	21.0	456	22.7	18.5	114.0	22.3	164	19.5	4.9	28.7	41.2	292	24.4	13.6	85.3	27.9	126.5	15.8	25.6
12	24.3	292	29.0	19.3	137.2	24.1	105	24.8	5.1	34.5	75.8	187	31.1	14.2	102.7	30.1	178.5	14.9	13.0
20	26.5	187	35.9	19.0	157.1	27.6	67	31.8	5.3	39.4	115.2	120	38.1	13.7	117.7	34.4	232.9	11.6	6.8
25	27.0	120	43.9	18.2	133.2	33.8											248.4	9.9	3.1
Quality 21																			
3	8.3	1111	7.2	4.6	0	36.1	357	0	0	0	0	754	8.8	4.6	0	43.9	0	0	11.3
5	14.4	754	14.2	11.9	30.2	25.3	242	9.4	1.7	6.78	6.78	512	16.0	10.2	23.4	30.7	30.2	6.0	15.1
8	19.3	512	20.5	16.9	76.8	22.9	165	15.7	3.2	17.3	24.1	347	22.4	13.7	59.5	27.8	83.6	10.4	17.8
12	22.1	347	25.5	17.7	107.6	24.3	111	21.1	3.9	24.1	48.2	236	27.3	13.8	83.5	29.5	131.7	11.0	12.0
20	23.9	236	30.7	17.4	146.3	27.2	76	28.7	4.9	33.0	81.2	160	31.5	12.5	113.3	33.1	194.5	9.7	7.8
25	24.3	160	36.1	16.4	136.0	32.5											217.2	8.7	4.5
Quality 19																			
3	8.0	1111	6.9	4.2	0	37.5	335	0	0	0	0	776	8.3	4.2	0	44.9	0	0	9.9
5	13.4	776	13.1	10.5	27.2	26.8	234	9.1	1.5	5.73	5.733	542	14.5	9.0	21.43	32.1	27.2	5.4	13.6
8	17.6	542	18.6	14.7	55.3	24.4	163	13.6	2.4	11.6	17.37	379	20.3	12.3	43.65	29.2	61.0	7.6	11.3
12	19.3	379	22.2	14.7	98.5	26.6	114	20.7	3.8	20.7	38.12	265	22.8	10.8	77.79	31.8	115.9	9.7	13.7
20	21.3	265	27.0	15.2	119.0	28.8	80	25.9	4.2	25.1	63.26	185	27.4	10.9	93.84	34.5	157.1	7.9	5.2
25	21.7	185	31.5	14.4	115.3	33.9											178.5	7.1	4.3

^a H_0 : top height (m); N : number of stems/ha; D_g : quadratic mean diameter at breast of height (cm); G : basal area (m^2/ha); V : commercial volume (m^3/ha); Vt: commercial volume accumulated in thinnings (m^3/ha); Hart: Hart-Becking index; VT: total commercial volume (m^3/ha); MAI: mean increment of volume (m^3/ha per year); CAI: current increment of volume (m^3/ha per year).

Other studies have indicated that wood density and mechanical properties are independent of growth rate or that fast-grown trees of ring-porous species have higher wood density and strength (Harris, 1981; Bhat, Bhat and Dhamodaran, 1987; Rajput, Shukla and Lai, 1991). More recently, a study on the wood properties of fast-grown plantation teak trees of different ages revealed that there were no significant differences in wood density, modulus of rupture (MOR), modulus of elasticity (MOE) or maximum crushing stress (Bhat, 1998). It was concluded that young trees (13 to 21 years of age) are not necessarily inferior in wood density and strength to older trees aged 55 and 65 years, and hence that the rotation age of fast-grown teak wood can be reduced without affecting the timber strength.

1.4. Forest Plantation Audit process and Objectives

Forest Audits generally assess and compliance with the forest management planning manual and the effectiveness of forest management activities in meeting the objectives set out in the forest management plan.

The specific objectives of forest Audit are to assess to what extent forest management planning activities comply with forest management plan and forest management principles. Another objective is to compare the planned forest management activities with actual activities undertaken and to remedy shortcoming identified in a previous audit. At finally the audit provide a conclusion stating whether or not the forest is being managed consistently with principles of sustainable forest management to achieve the set objectives of forest management plan. Present teak plantations need to be prepared the comprehensive forest management plan with set objectives.

1.4.1. Requirement for conducting the audit

There is sufficient or appropriate information to conduct the audit , in addition there are adequate resources and co-operation from the auditee to conduct audit process. The audit team must be independent.

1.4.2. Objectives of present forest inventory and Audit of Teak Plantation in Batticaloa, in Sri Lanka

- I. To inventory the teak plantation to get Teak tree stock and tree growth parameters.
- II. To decide next silvicultural treatments such as pruning, thinning and some maintenance activities of plantation like fire lines, weeding, fertilizing based on information gathered from forest inventory and field examination.
- III. To predict future tree growth, timber production and estimated timber value . This forecasting will help to take the remedial measures to manage the plantation efficiently to achieve the maximum benefit from the plantation.
- IV. To remedy shortcoming identified in a previous audit and assess the forest management activities.

2. Methodology of Forest inventory

Sound forest management depends on the quantity and quality of information available on the forest. This information is obtained from forest inventories. Forest inventory is the activity of data collection that helps generating the required information base on the forest resource within an area of interest. There are three main factors, which influence the cost of an inventory: Type of information required; Standard of accuracy; Size of area to be surveyed and the minimum size of unit area in the forest.

A good forest inventory;

- I. Should be conform to the objectives
- II. Should provide adequate precision
- III. Methodologically sound & follow statistical sampling criteria
- IV. Have comprehensive transparent reporting & documentation
- V. Overall credibility

In this inventory process, important of the above criteria is considered and followed.

2.1. Items recommended for conducting forest inventory and monitoring exercises

Items needed for all field inventory or assessments. Field assessment datasheets (current and previous) Field vest, Plastic flagging (at least three different colors) Mechanical pencils, Sharpie permanent ink pen, Compass, Calculator, Small Ruler (metric & English), 75' or 100' Spencer tape w/dbh tape, Clinometers, Clipboard or datum

Stand map, plots mapped, Small pocket sized notebook, Digital camera

Numbered tree tags (check for numbers that have not been used) Unmarked bearing tree tags for scribing

Rebar & plastic pipes (for replacement if missing), Tree paint (spray can): orange or other bright color, First-aid kit, Water, Cell phone

2.2. Temporary vs. Permanent Plots

When conducting a forest inventory, most landowners install temporary plots. When the stand is re-inventoried in the future, plot locations are different. This is the simplest inventory method and is recommended for landowners who have minimal time to devote to forest inventory. **Permanent inventory plots** are often used on large ownerships and are the most precise method of monitoring forest change over time. To establish “permanent” plots, plot centers or corners are marked with a stake or other marker and the variables of the forest stand within the plot are re-measured through time.

Asia Teak Group audit inventory the permanent square shape plots are used and for forest management review works, the temporary circular plots were used.

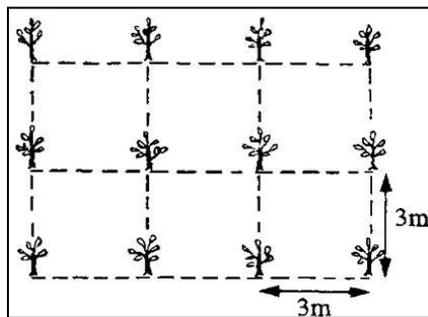


Figure 2. Corner boundary tree, painted with yellow color in square shape Plot and DBH measurement taken by diameter tape and height measurement of tree taken, by pole in Block 2 and plot number 3 and Block 2 and plot 1 in Batticaloa estate belong to Asia Teak.

Diameter at breast height (1.3m) is measured by diameter tape. Inventory team follows all the standard and rules recommended in this regard.

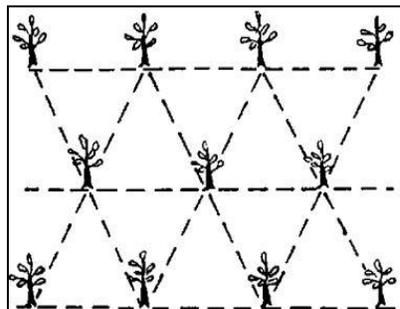
2.2.1. System of Planting

Square system: This system is considered to be the simplest of all the system and is adopted widely. Under this system, intercultural operations, spraying, harvesting etc., can be done conveniently and easily and irrigation can be done in two directions.



Square system

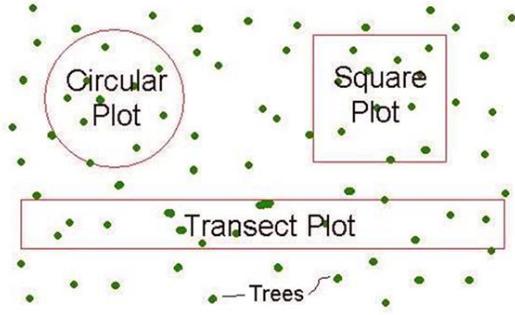
Triangular system : In this system, trees are planted as in the square system but the plants in the 2nd, 4th, 6th and such other alternate rows are planted midway between the 1st, 3rd, 5th and such other alternate rows. This system has no special advantage over the square system except providing more open space for the trees and for intercrops.



Triangular system

2.2.2. Plot shape

In this study, square plot are used and suggested plot size based on the stocking shown bellow. However we have used 40m x 40 m square shape plots in most of time.

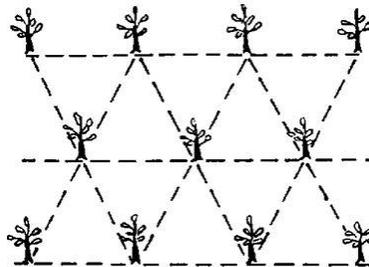


STOCKING RATE (STEMS/HECTARE)	PLOT SIZE (HECTARES)	RADIUS OF CIRCULAR PLOT (METRES)
100	0.2	25.2
200	0.1	17.8
400	0.05	12.6
500	0.04	11.3
600	0.033	10.2
800	0.025	8.9
1000 +	0.02	8.0

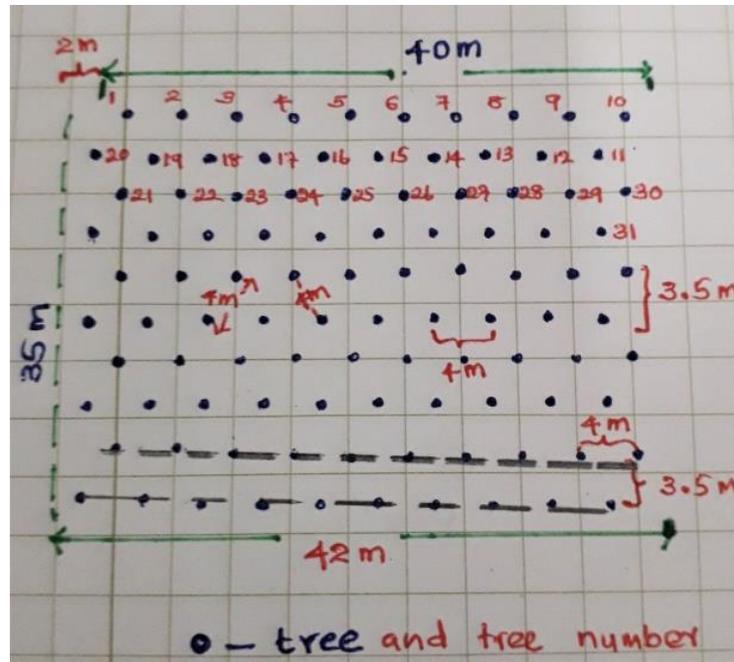
Various plot shapes

2.2.3. Plot size and planting system of Sri Lankan Asia Teak Plantation

Size of the plots is measured by predetermined of tree spacemen (distance) and number of trees in each row.



All the plots of Puttalam are 80m x 20 m (1600 m²)



All the plots of block 01, Block 3, Block 4, and Block 5 of Batticalao are 42m x 35m. (1470m²)

2.3. Basics of mensuration (Tree variables measurement)

- a) Diameter measurement of a single standing tree
- b) The diameter at breast height (dbh)

The standard position for diameter measurement at standing tree is at breast height. It is defined at 1.30 meter above ground in most countries. Calipers and diameter tape are the most commonly used instruments.

2.3.1. Diameter tape

There are diameter tapes from which the tree diameter can be directly read. Tree diameter can also be determined from circumference measurement which can be done by diameter tape or any tape since circular tree stem shape is assumed.

$$C = 2 \pi r = d; \quad d = C / \pi$$

In this study, Diameter tape is used.



Figure 2.1: Diameter tape used for forest inventory

2.3.2. Positions of diameter measurement at different conditions

We followed following standard governing rules when take measurement of diameter at breast height of tree stem. Ex: clean the bole surface where we measure the stem diameter, diameter tape always correctly handled and read data carefully for reporting.

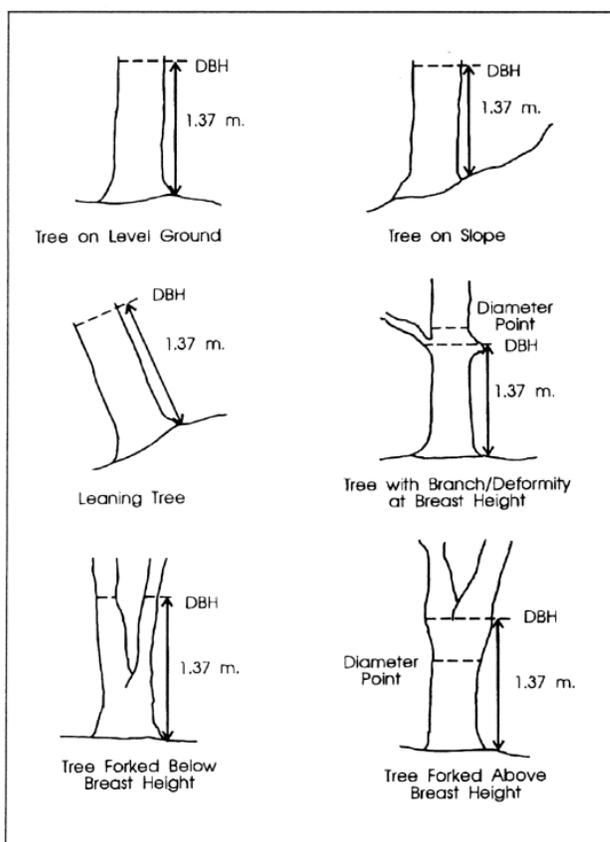


Figure 2.2: Standard rules governed to measure diameter at breast height

2.3.3. Tree height measurement

Height is a tree variable that is used to estimate or determine the volume of a tree. The total height is the distance between the ground and top of the tree and bole height is the distance between the ground and the Crown Point. Merchantable height: the distance between the ground and the terminal position of the last useable portion of the tree stem. Tree height is defined to be the perpendicular distance between the ground level and the

top of the tree. While, Tree length is the distance between the stem foot and the top along the stem

2.3.3.1. Method of tree height measurement

There are two methods, one is direct method which involves using height measuring rods only for small trees (see right). Other method we used is trigonometric principles. Sunto hypsometer used as instrument for this purpose



Figure 2.3. Total Tree height was measured by hypsometer and a pole, used instrument of sununto meter is shown in above

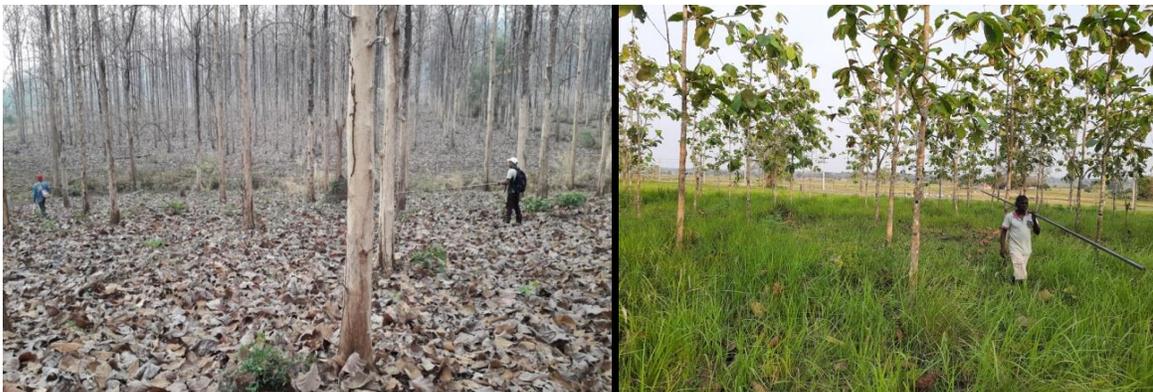


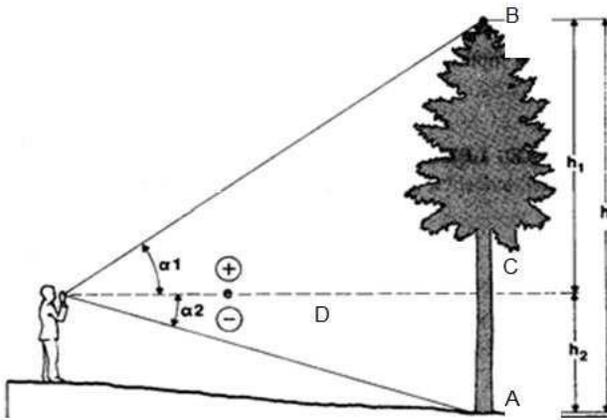
Figure 2.4. Correct horizontal distance between tree and height observer is being positioned

2.3.3.2. General steps for Hypsometer are bellow

- ❖ Stand at a fixed horizontal distance from the base of the tree (usually 10, 15, 20, 25 meters, and so on)
- ❖ Sight at the top of the tree and read the value ‘A’ (top reading)
- ❖ Again sight at the bottom of the tree and read the value ‘B’ (bottom reading)
- ❖ Then the total height of the tree is top reading ‘A’ minus bottom reading ‘B’
- ❖ Bottom reading +ve or -ve (above and below eye level)

Height measurement can be taken using clinometer as shown figure 2.3.

Figure 2.5: Tree height measurement on a flat terrain.



$$\begin{aligned} \tan \alpha_1 &= BC / D \\ BC &= \tan \alpha_1 \cdot D \\ \tan \alpha_2 &= AC / D \\ AC &= \tan \alpha_2 \cdot D \\ AB \text{ (height)} &= BC + AC \\ AB &= \tan \alpha_1 \cdot D + \tan \alpha_2 \cdot D \\ AB &= D (\tan \alpha_1 + \tan \alpha_2) \end{aligned}$$

3. Results of inventory of teak plantation

3.1. Teak Plantation of Batticaloa

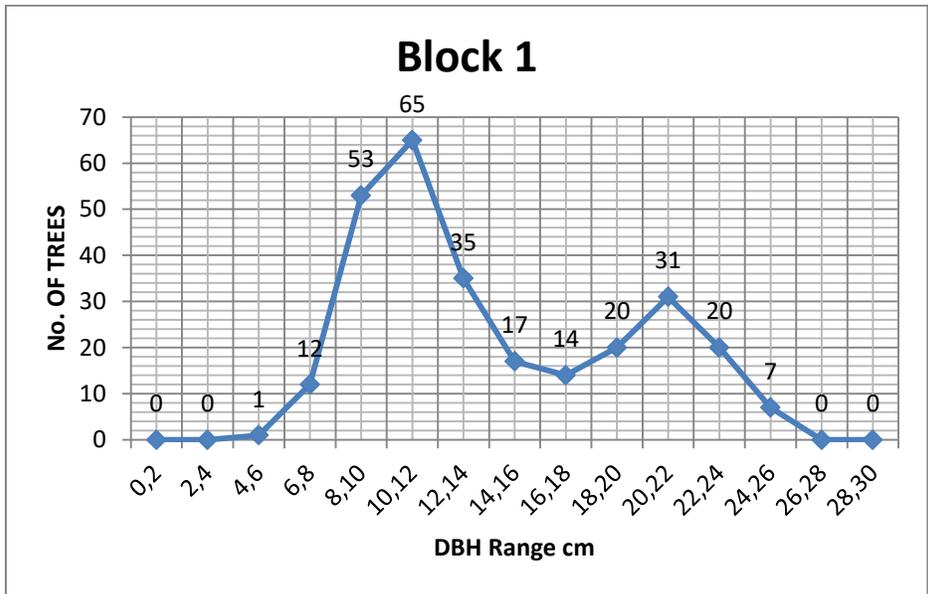
Table 3.1. Number of trees and tree mean DBH values in plots in Batticaloa

Plot number (P)	Block 01			Block 02			Block 03		
	No.of trees	Mean DBH (cm)	Mean height (m)	No. of Trees	Mean DBH (cm)	Mean height (m)	No. of Trees	Mean DBH (cm)	Mean height (m)
1	90	11.1	9.7	92	13.7	11.3	93	12.5	10.8
2	89	10.8	9.8	66	10.4	9.8	96	14	12.3
3	96	20.4	18.5	79	14.2	10.7	88	13.8	11.1
4				71	10.6	8.2	90	10.3	8.6
Mean	91	14.3	12.6	76	12.4	10	92	12.7	10.7
Total	275			308			367		

Teak Tree Inventory Audit Report – Batticaloa Plantation

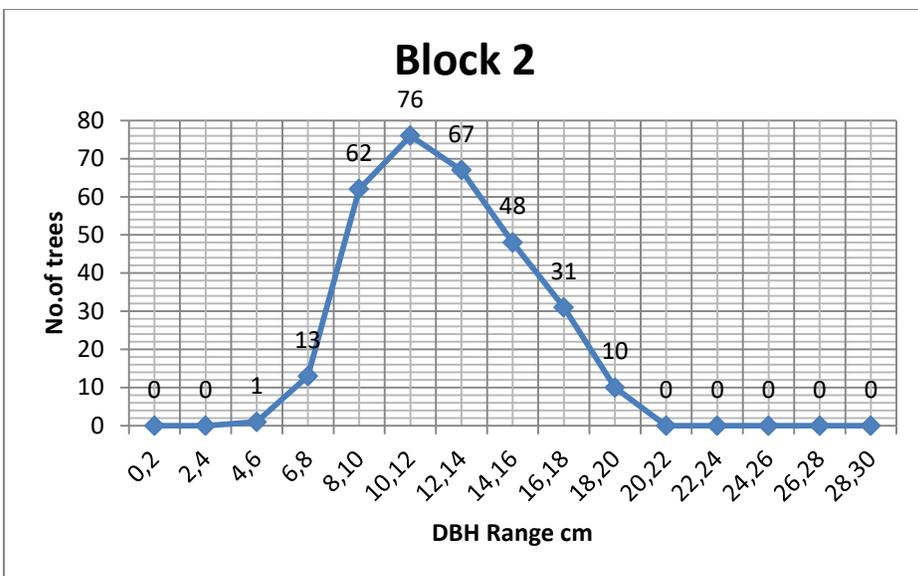
Plot number (P)	Block 04			Block 05			
	No. of trees	Mean (cm)	DBH	Mean height (m)	No. of trees	Mean DBH (cm)	Mean height (m)
1	92	14.2		10.7	43	8.6	8.1
2	89	13.9		13.2	53	12.5	8.5
3	52	8.6		7.6	73	12.6	9.5
4					76	10.5	8.3
5					64	11.3	9.6
6					89	13	10.9
Mean	77	12.8		10.5	66	11.7	9.1
Total	233				398		

Graph 3.1: Number of trees against to average DBH range values in Blocks in Batticaloa



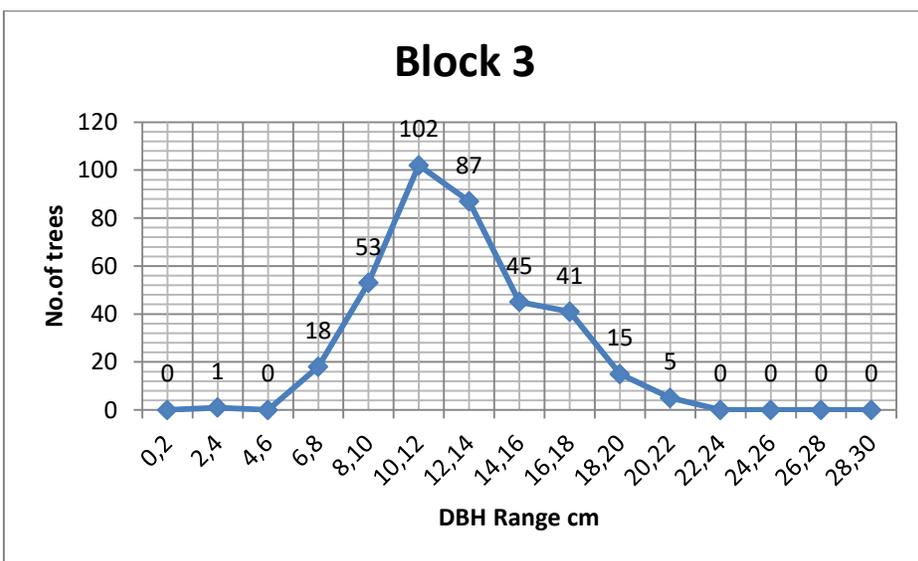
Out of 275 of trees, 109 trees are having more than 14 cm dbh. Mean dbh is 14.3 cm

It can be assumed that in block no.1. out of 2036 trees, There are 806 trees having more than 14 cm DBH category.



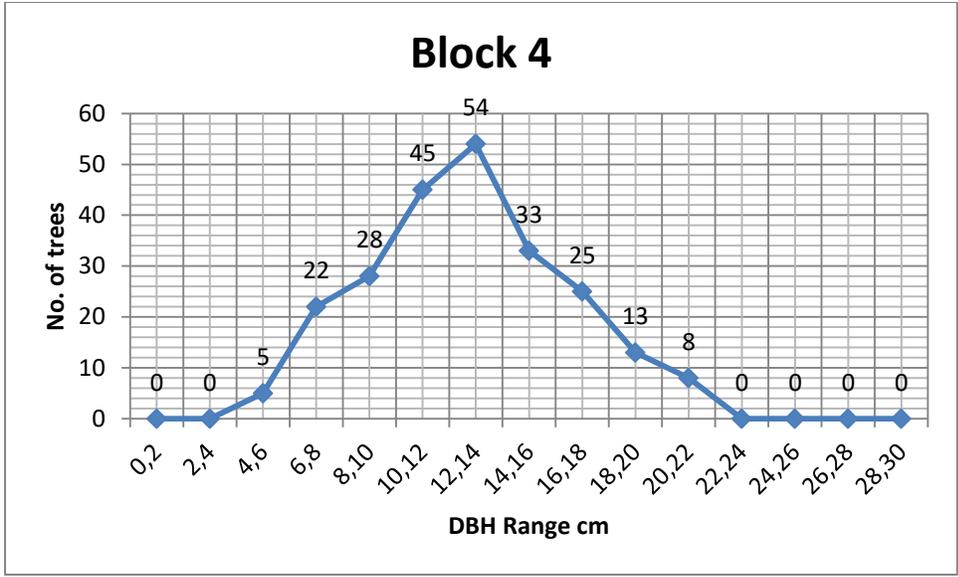
Out of 308 of trees, 89 trees are having more than 14 cm dbh. Mean dbh is 12.4cm

It can be assumed that in block no.2. out of 3487 trees, There are 1007 trees having more than 14cm DBH category.



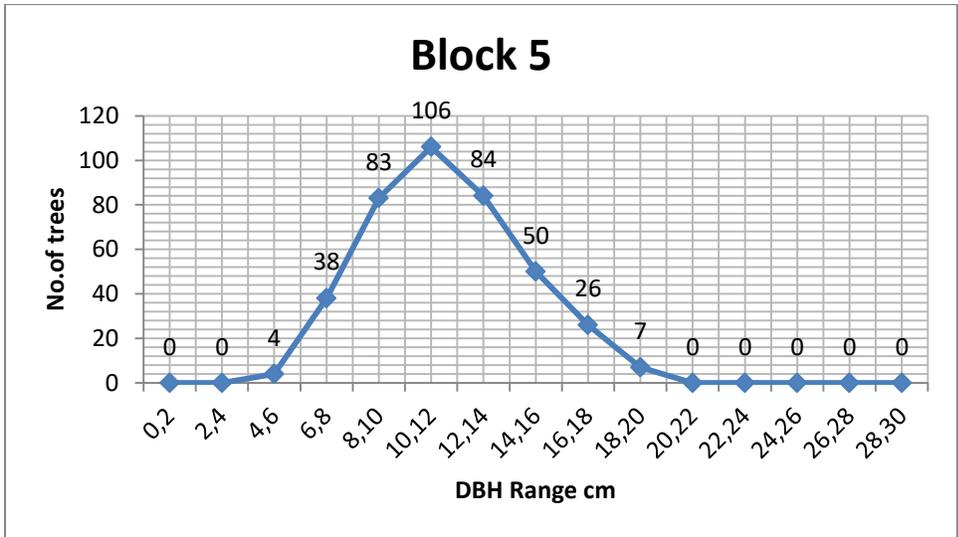
Out of 367 trees, 106 trees are having more than 14cm dbh. Mean dbh is 12.7cm

It can be assumed that in block no.3. out of 3055 trees, There are 882 trees having more than 14cm DBH category.

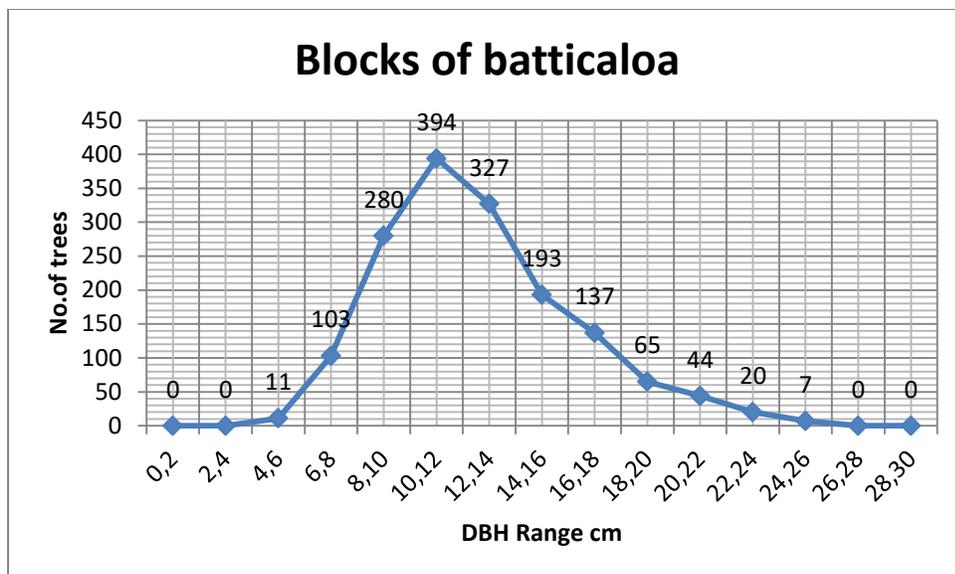


Out of 233 trees, 79 trees are having more than 14cm dbh. Mean dbh is 12.8 cm

It can be assumed that in block no.4. Out of 2457 trees, There are 833 trees in having more than 14cm DBH category.



Mean block DBH is 11.7 cm. Out of 398 trees, 83 trees are more than 14 cm dbh value. Out of total block 5 trees of 4423 there are 922 trees are more than 14cm of DBH.



Mean block 5 DBH is 12.7cm. Out of 1581 trees, 466 trees are more than mean dbh value (14 cm). Out of total block trees of 15458, 4556 trees are more than 14 cm of DBH.

Figure 3.1. View of different blocks in Batticaloa plantation

Block 01-plot 03- Mean DBH is 19.65cm and height is 18.5m. Selective thinning is recommended due to canopy competition.



Block 5-plot 01.-DBH measurement is taken. Mean DBH is 8.6 cm and height is 8.1m



Instructions to field staff given by Mr. Jayalath in order for better performance.



Christen Hypsometer is used to measure the tree height of shorter trees.



Block 5-plot 02-Mean DBH is 12.5cm and height is 8.5m



Block 5-plot 03. Mean DBH is 12.6 cm and height is 9.5 m. Mechanical weeding done properly



Block 2 plot 1: DBH is 13.7 cm and height is 11.3m.

Table 3.2. Estimated number of trees having more than its mean DBH value in Batticaloa teak Plantation

Estate	Block no and its mean dbh value.	No. of trees more than its 14 cm DBH in Block and its %
Batticaloa	1 and 14.3 cm	806 (39%) from 2036 trees
	2 and 12.4 cm	1007 (28%) from 3487 trees
	3 and 12.7 cm	882 (28%) from 3055 trees
	4 and 12.2 cm	833 (33%) from 2457 trees
	5 and 11.7 cm	922 (20%) from 4423 trees
	Estate total mean 12.7 cm	4556(29%) from 15458 trees

Table 3.3. Mean block growth parameter of Batticaloa plantation

Block no.	Total tree number in plots	Mean tree number per ha	Mean DBH (cm)	Mean Height (m)
Block 1	275	619	14.3	12.6
Block 2	308	517	12.4	10
Block 3	367	625	12.7	10.7
Block 4	233	523	12.2	10.5
Block 5	398	448	11.7	9.1
block mean	316 (total 1581)	546	12.7	10.5

Table 3.4 Growth parameters and growth rate of Batticaloa teak plantation based on mean data of samples plots taken. Size of plot is 42mx35m (1470m²)

Table 3.4.1.		Batticaloa Block 1 (planted area approx. 3.36 ha) Planted year 2012.july to 2013 December.					
Age (year)	Measurement taken year	Total no. of tree	No. of trees per ha	DBH (cm)	Height (m)	CIA of DBH(Ht)	
2	2014	2474	736				
3	2015	2499	743	6.3	5.0		
4	2016	2380	708	8.1	6.0	1.8(1)	
5	2017	2292	682	9.0	6.6	0.9(0.6)	
6	2018	2305	686	10.6	8.2	1.6(1.6)	
7	2019	2230	663	11.4	9.1	0.8(0.9)	
8	2020	2129	633.6	12.65	11	11.25(1.9)	
9	2021	2041	628	13.57	11.4	0.92(0.4)	
10	2022	2036	619	14.3	12.6	0.7(1.2)	

CIA= Current Annual Increment

Table 3.4.2.		Batticaloa Block 2 (planted area approx. 6.75 ha) Planted year 2012.july to 2013 December.					
Age (year)	Measurement taken year	Total no. of tree	No.of trees per ha	DBH (cm)	Height (m)	CIA of DBH(Ht)	
2	2014	4532	671				
3	2015	4355	645	2.7	2.3		
4	2016	4213	624	5.0	4.0	2.3(1.7)	
5	2017	4114	609	6.1	4.7	1.1(0.7)	
6	2018	4159	616	8.4	6.1	2.3(1.4)	
7	2019	4308	638	9.7	6.9	1.3(0.8)	
8	2020	3742	554	10.27	7.4	0.57(0.5)	
9	2021	3633	513	11.45	8.33	1.18(0.93)	
10	2022	3487	517	12.4	10	0.95(1.6)	

Teak Tree Inventory Audit Report – Batticaloa Plantation

Table 3.4.3		Batticaloa Block 3(planted area app. 5.5 ha ?) Planted year 2012.july to 2013 December.					
Age (year)	Measurement taken year	Total no. of tree	No. trees per ha	of DBH (cm)	Height (m)	CIA of DBH(Ht)	
1	2014	4386	797				
2	2015	4248	772				
3	2016	4355	792	4.0	3.2		
4	2017	4169	758	6.1	4.9	2.1 (1.7)	
5	2018	3972	722	7.3	5.3	1.2 (0.4)	
6	2019	3982	724	8.7	6.4	1.4 (1.1)	
7	2020	3350	629	9.64	7.7	0.94 (1.3)	
8	2021	3080	627	11.21	7.45	1.57	
9	2022	3055	625	12.7	10.7	1.5 (3)	

Table 3.4.4		Batticaloa Block 4 (planted area app. 4.73 ha) Planted year 2012.july to 2013 December.					
Age (year)	Measurement taken year	Total no. of tree	No. trees per ha	of DBH (cm)	Height (m)	CIA of DBH(Ht)	
1	2014	3338	705				
2	2015	3102	655				
3	2016	3322	702	4.2	3.5		
4	2017	3240	685	5.3	4.1	1.1(0.6)	
5	2018	3162	668	7.5	5.6	2.2(1.5)	
6	2019	3282	694	8.3	6.3	0.8(0.7)	
7	2020	2729	577	9	6.6	0.7(0.3)	
8	2021	2499	530	10.6	7.48	1.6(0.88)	
9	2022	2457	523	12.2	10.5	1.6(3)	

Table 3.4.5		Batticaloa Block 5(planted area app. 9.2 ha ?) Planted year 2012.july to 2013 December.					
Age (year)	Measurement taken year	Total no. of tree	No. trees per ha	of DBH (cm)	Height (m)	CIA of DBH(Ht)	
0	2014	6625	720				
1	2015	5926	644				
2	2016	6760	734				
3	2017	6061	658	4.0	3.3		
4	2018	6320	686	6.6	5.2	2.6(1.9)	
5	2019	6343	689	7.2	6.0	0.6(0.8)	
6	2020	4832	493	8.35	6.6	1.15(0.6)	
7	2021	4519	445	9.84	7.04	1.49(0.44)	
8	2022	4423	448	11.7	9.1	1.2(2.1)	

Table 3.5. Batticaloa block growth parameter with age

Batticaloa all Blocks Planted year 2012.july to 2013 December				MAI and (CAI)	MAI and (CAI)
Age (year)	Measurement taken year	DBH (cm)	Height (m)	For DBH (cm)	For Height (m)
3	2015	4.24	3.46	1.41	1.15
4	2016	6.22	4.84	1.55 (1.98)	1.21 (1.38)
5	2017	7.42	5.64	1.48 (1.2)	1.13 (0.8)
6	2018	8.87	6.72	1.48(1.45)	1.12 (1.08)
7	2019	9.93	7.57	1.42 (1.06)	1.08 (0.85)
8	2020	10	7.86	1.25 (0.07)	0.98 (0.29)
9	2021	11.34	8.3	1.26 (1.34)	0.92 (0.44)
10	2022	12.7	10.5	1.27 (1.36)	1.08 (2.2)

Table 3.6. Sri Lankan Teak Plantation tree count.
Comparison Tree Audit 2021-2022 in Batticaloa

Estate Name	Block number	Geophysics count trees 2021						Geophysics count trees 2022					
		Total good trees	No.of small/poor trees	Marked for thinning	Reserved tree	Total trees	Differences 2019 vs 2020	Total good trees	No.of small /poor trees	Marked for thinning	Reserved trees	Total trees	Differences 2022 vs 2021
Batticaloa	B1	1573	230		238	2041	101	1564	234		238	2036	(5)
	B2	2940	693			3633	566	2917	570			3487	(146)
	B3	2833	249			3082	632	3016	39			3055	(27)
	B4	2321	178			2499	553	2414	43			2457	(42)
	B5	3619	900			4519	1511	(3592)	831			4423	(96)
	Total all blocks	13286	2250		238	15774	3363	13503	1717		238	15458	(316)

Table 3.7. Sample plots information, planted area and tree inventory data in year 2022 of Batticaloa,

Estate	Block no.	Total trees in block	Estimated planted area (ha)	No. of Plots	Plots area in block (m ²)	Year 2022			
						No. of trees measured for DBH in Block	No of trees for ha.	Average DBH (cm)	Average height approx.(m)
Batticaloa	1	2036	3.66	3	4410 (1470x3)	275	619	14.3	12.6
	2	3487	7.35	4	5880 (1470x4)	308	517	12.4	10
	3	3055	4.8	4	5880 (1470x4)	367	625	12.7	10.7
	4	2457	4.69	3	4410 (1470x3)	233	523	12.2	10.5
	5	4423	9.1	6	8820 (1470x6)	398	448	11.7	9.1
	total	15458	29.5 ha from 48 ha	total 20	Total 29400 (2.94ha)	(mean 316) Total 1581	Average 546	AVERAGE 12.7	Average 10.5

Table 3.8. Comparison of tree parameters between year 2021 and 2022 in Batticaloa plantation.

Estate	Block no.	No. of Plots	Year 2021				Year 2022				Variance in DBH (cm) & Height (-) 2022 vs 2021
			No. of trees measured for DBH	No of trees for ha.	Average DBH (cm)	Average height appro.(m)	No. of trees measured for DBH	No of trees for ha.	Average DBH (cm)	Average height appro.(m)	
Batticaloa	B1	3	277	628	13.57	11.37	275	619	14.3	12.6	0.73cm (1.23m)
	B2	4	302	513	11.45	8.33	308	517	12.4	10	0.95cm (1.67m)
	B3	4	369	627	11.2	7.45	367	625	12.7	10.7	1.5cm (3.25m)
	B4	3	234	530	10.64	7.48	233	523	12.2	10.5	1.56cm (3m)
	B5	6	393	445	9.84	7.04	398	448	11.7	9.1	1.86cm (2m)
		Total 20		Total 1575	Ave. 549	AVE. 11.34	Ave. 8.3	Total 1581	Ave. 546	AVE. 12.7	Ave. 10.5

Table 3.9. Tree volume and other growth parameters of plantations were estimated based on age of plantation, form factors and inventory data of Batticaloa plantation.

Tree age or inventory year 2022	AGE OF THE PLANTATION IS 10 YEARS OLD Planted year 2012,july to 2013 December AND FORM FACTOR IS 0.45							
Block NO.	Total trees	No.of stems/ha	DBH (cm)	Height (m)	Per Tree volume (m3)	Trees volume m3/ha	Total volume In block (m3)	MAI (m3/ha/year)
1	2036	619	14.3	12.6	0.091	56.3	185	5.63
2	3487	517	12.4	10	0.054	27.9	188	2.79
3	3055	625	12.7	10.7	0.060	37.5	183	3.75
4	2457	523	12.2	10.5	0.055	28.8	135	2.88
5	4423	448	11.7	9.1	0.044	19.7	194	1.97
	(15458)	Ave. 546	AVE. 12.7	Ave. 10.8	Mean=0.0615	Mean=33.59	GRAND TOTAL=(885)	Grand mean=3.3

Table 3.10. Determination of site index based on growth parameters of past years of Batticaloa

Batticaloa plantation age is 10 years (Batticaloa, **Planted year 2012.july to 2013 December)**

Estate	Block no.	No. of Plots	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	DBH differences from Year of first measurement to 2022 and (Mean Increment of DBH cm)
			Ave. DBH (cm)	Ave. DBH (cm)									
Batticaloa	1	3				6	6.6	8.2	9.1	12.65	13.57	14.3	8.3 (mean DBH 1.4)
	2	4			2.9	5	6.1	8.4	9.7	10.27	11.45	12.4	9.5 (1.2)
	3	4				4	6.1	7.3	8.7	9.64	11.2	12.7	8.7 (1.2)
	4	3				4.2	5.3	7.5	8.3	9	10.64	12.2	6.48 (1.2)
	5	6					4	6.6	7.2	8.35	9.84	11.7	7.7 (1.1)
	Estate average				2.9	4.8	5.62	7.6	8.6	9.98	AVE. 11.34	12.7	9.8 (1.2)

4. Forest management and silvicultural activities observed

4.1. Application of fertilizer.

Year 2020

13:15:13 NPK 400g per tree applied during the period of 2021 feb to 2021 March.

500g of Dolomite per tree applied for 1200 trees and fertilizer is available for another 3800 trees.

10kg organic fertilizer per tree applied for 2800 trees (2300 trees in block 4 and 500 trees in block (3). This was done during the period of 2020 march to 2020 may.

Year 2021.

Compost and cowdung application done during May and june 2021, NPK application completed Block 4 during may/June 2021.

4.2. Pruning activities

Year 2020

First round of pruning was completed in 2020 may to 2020 June.

Second round of pruning was started from 2021 February.

Year 2021

Pruning in Block No.5, 3 and 2 completed July/September in 2021

4.3. Weeding

Year 2020

First round of weeding was completed during the period of 2020 June to 2020 December.

Second round of weeding started from 2021 February.

Year 2021-22.

Second round of Weeding completed during February 2021 to February 2022.



*Block 1 plot 3.
DBH is 20.4cm
and height is
18.5m*

*Pic 1. Teak
trees in Block 1
Plot3 are
having canopy
competition.
Extra trees
needs to be
removed by
identified*



Cleaning of damaged bark area of teak stem and applying of fungicide (Candasan).



The chemical used for trunk canker.



Fungicide “Candasan” has been applied for suspected teak stem canker



Samples of wounded trunk area were taken for the Laboratory and colonies of fungus develop in Petri dish as shown in picture.

5. Observation, Conclusions and recommendation

- I. Most of the recommendations given in 2021 audit report have already been implemented such as
 - I.1. Continuous elephant fence maintenance and rebuild need to be reviewed and rectified to stop of elephant damage to Teak Plantation of Batticaloa.
 - I.2. NPK application for Block 4 has been completed during May to June 2021. The Slowest tree growth was observed in Block 5 in which tree DBH is 11.7cm and 20% of trees are less than 14cm DBH. However it must be emphasized that age of this trees are two year younger (two years) than Block 1 and 2 and one year younger than blocks 3 and 4. When we compare the growth results we will have to consider age differences among the Blocks. Soil improvement methods are urgent for particularly following plot area of Blocks such as Block 1 plot 1 and 2, Block 2 plots 2 and 4. Block 4 plot 3 and Block 5 plot 1.

Note: Application of soil improvement method and soil erosion prevention methods must be applied where site has steep slope. It is observed that organic compost (cow dung) has been applied in between two row of planting tree lines. It is recommended to apply these cow dung only close proximity to tree. Otherwise most of compost quantity is utilized by weeds. Because teak trees root system has not growth enough widely to reach the compost. This practice is being implemented.
 - I.3. In all the sites, concrete posts at corner of sample plot have be reestablished. This recommendation has been implemented. Otherwise unnecessary time is wasted to find the boundary of the plots.
 - I.4. Adventitious shoots have been removed. Pruning of the adventitious shoots should be carried out only after required training given under close supervision.
 - I.5. Weeding has been done systematically.
- II. It is observed that trees in some blocks particularly Block 1 plot 3 (see pic 1 page 31) are competing for sunlight hence specific thinning schedule to be applied for particular areas. The average tree stem per ha (653) is much higher than mean plantation density (546 trees/ha) in this plot area.

Note: When excess trees build up the canopy and root completion among the trees in plantation, those inferior trees must be thinned out (removing whole tree) in order to give space for good trees to grow freely and produce larger cylindrical bole. Selective thinning must be applied after careful study of tree growth parameters given in graphs 3.1 by one to one tree inspection. Thinning regime can be decided in relation to tree age and number of stem /ha, canopy closer, tree inventory data and tree annual rings information.

- III. Control fire or fire lines must be properly maintained.

iv. following finding can be made on growth parameter analyzed development by this study.

Results section of this report shows all the necessary information from planting year of this plantation to present audit year. Mean DBH and height have increased from 2021 to 2022 as 1.36 cm and 2.2 m respectively. Number of trees per hectare has reduced from 549 ha to 546 per ha from 2021 to 2022. We need to prepare thinning regime and reduce trees number per ha until harvesting stage. The mean tree volume for ha has increased from 25.2 in 2021 to 33.6 m³ in 2022, Furthermore it was estimated that this plantation contain of 708m³ in 2021 and it has increased to 885m³ in 2022.

Finally it can be concluded that Batticaloa Teak plantations are healthy and good condition. There is good potentiality to get better growth increment particularly for diameter growth for next 10 years if the plantation is maintained and managed scientifically.

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