TEAK TREE INVENTORY AND AUDIT REPORT-2022

CONDUCTED FOR

ASIA TEAK GROUP

AT

Puttalam Teak Plantation.
Sri Lanka

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2022 March

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Executive summary

Puttalum teak plantation is one of three estates of Teak plantations namely Batticoloa, Anamaduwa and Puttalum plantations , managed by Asia Teak Tropical Plantation were inspected by Mr. J.M.P. Jayalath, Mr. Eranda Rathnamalala and me on 2022.2.13 in order to inventories and audit the tree stocks of plantations. 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. We certify that the inspected plantations are presently in reported condition. DBH measurements of 447 trees were taken from Puttalum plantations.

Puttalum Teak Plantation

Five sample plots having with total sample area of 8000 m2 have been permanently setup in different locations in Puttalum plantation. It is found by this study that total estimated planted area is 8.3ha (out of 10ha) and sample plots represent 10.6 % of population. In this study, 447 trees were measured for DBH measurement and around 45 trees for height measurement taken by hypsometer or pole. We applied all the international standards when measuring the tree parameters such as DBH and Height. (See page 17-20). There are 4581 trees in this plantation in which 447 trees measured for DBH, which represent 9.7% of population.

The inventory result shows that there are 4581 trees (4400 good trees and 181 reserved trees.). Small/thinning trees were removed in July 2021.The average DBH and Height of trees in the estate is 18.5 cm and 14.8 m respectively. It is found that average trees per ha is 551. In 2021 tree count audit, out of 5050 (before thinning) ,(4608 after thinning) total trees, there were 4608 good trees, 442 marked for thinning. In 2022 audit it is found that there are 27 trees less than total tree number of 2021 audit which may be thinned out or uprooted. Details of block wise tree information are shown in table 3.2 and (3.9).

Analyzing inventory tree data, it is found that more than 56 % of trees are having DBH more than 16-18 cm of mean DBH value for Puttalum plantation that means, out of 4581 trees. There are 2603 trees having more than 16-18cm DBH.

Plantation tree DBH distribution results are given in graphs, see page 21. Growth parameters from establishment of the plantation are summarized in table 7,8,9 and 10.These findings can be used for future planning of thinning and final mode of harvest.

After analyzing the last 10 years of growth (DBH) data of 2014-2022, mean annual increment of DBH and Height is 1.68 cm and 1.34 m respectively. This site growth parameters are useful to find the complied 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(see table 14 page 26). The finding is that tree form factor is around 0.45. Total tree volume of the Puttalum plantation was estimated based on mean DBH, Mean Height and Form factor. The mean volume per tree of Puttalum plantation was found as 0.183m^3 for sample trees which was 0.179 for total population. The mean tree volume for ha is 95.8m^3. Furthermore it is estimated that this plantation contain of 819m^3. Growth parameters from establishment of the plantation are summarized in table 8. 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 as much as possible to get 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). Based on that thinning was carried out in July 2021. Suitable Yield table will solve this question further.

These findings can be used for future planning of thinning and final mode of harvest. If we carefully and scientifically handle this valuable tree information, we will able to achieve highest turnover from this plantations at end of felling rotation.

Stem canker's area of Teak must be taken with seal plastic storage and culture it for identification of pathogen. After identification of pathogen, it is easy to find solutions.

Finally it can be concluded that Puttalum Teak plantations in Sri Lanka are healthy and good condition. There are much more potential to get more growth increment particularly for larger tree stem diameter for next 9 years if the plantation is maintained and managed scientifically using selected prepared yield table.

Inventory team work under Corona prevention instruction.

1. Introduction

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

Teak (*Tectona grandis* 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

About 50%

About 50%
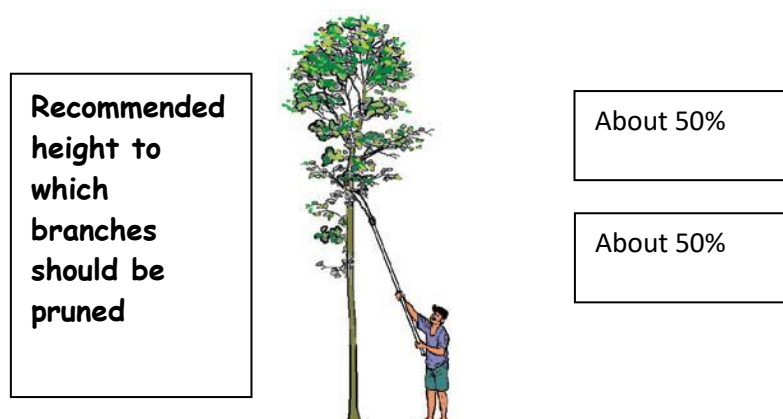
1.2.2 Thinning

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.
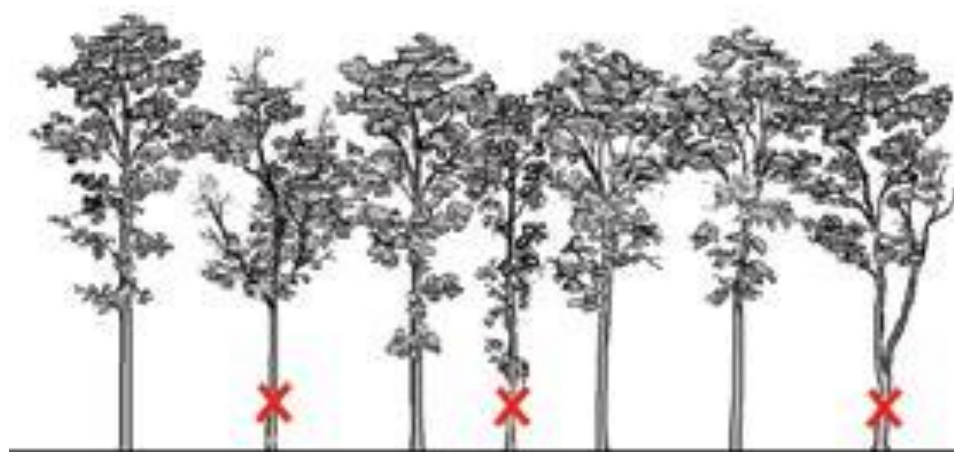
Table 1:   Trees left after thinning based on tree height

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

Table 2: Thinning regime developed for Puttalama plantation

Age/ Year	Main crop before thinning					Crop removed				
	Tree No.	Trees / ha	Mean DBH (cm)	Mean Height (m)	Tree Vol. (m³) or Tree Vol. / ha	Tree No.	Trees / ha	Mean DBH (cm)	Mean Height (m)	Tree Vol. (m³) or Tree Vol. / (ha)
9/2020	5093	597	16.37	12.4	0.117/69.8					
10/2021	5050	608				469	56	First thinning		
11/2022	4581	551								
12/2023	4581	551								
13/2024	4581	551								
14/2025	4581	551								
15/2026	4581	551				670	80	Second thinning		
16/2027	3911	471								
17/2028	3911	471								
18/2029	3911	471								
19/2030	3911	471								
20/2031	3911	471	Final harvesting							

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 Batticoloa, Anamaduwa and Puttalum teak plantation.
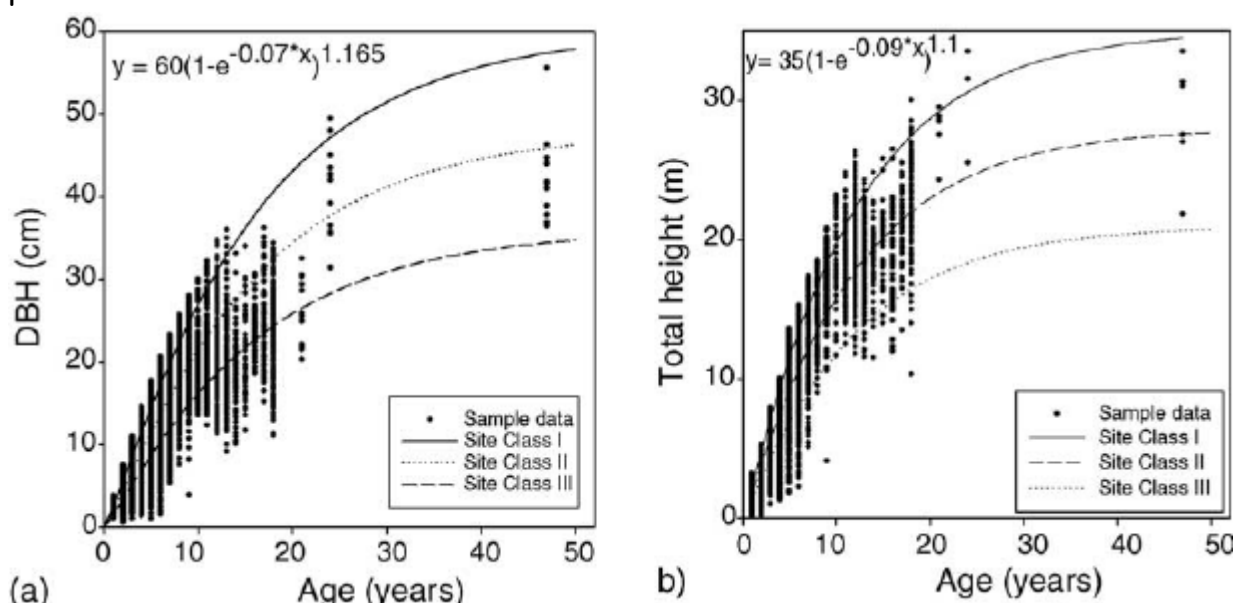
(a) Teak growth curve : DBH against age (b)Teak growth curve : Total height against age

Table 3: 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 4: 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

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.

1.5 Objectives of present forest inventory and Audit of Teak Plantation in Anamaduwa in Sri Lanka
a) To inventory the teak plantation to get Teak tree stock and tree growth parameters.
b) 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.
c) 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.
d) 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;

    a) Should be conform to the objectives

    b) Should provide adequate precision

    c) Methodologically sound & follow statistical sampling criteria

    d) Have comprehensive transparent reporting & documentation

    e) Overall credibility

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

2.1 The following items are 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, Clinometer, 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

2.1.1 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 1 : Plot number and one corner post of square shape plot in estate belong to Asia Teak

2.2 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.

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.
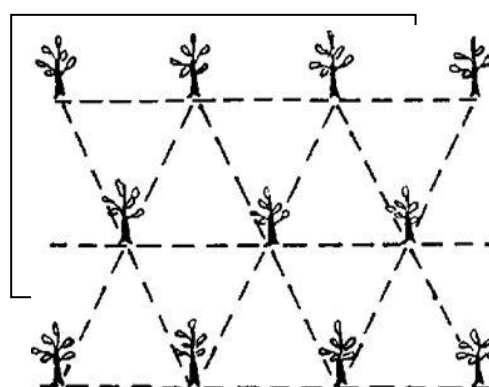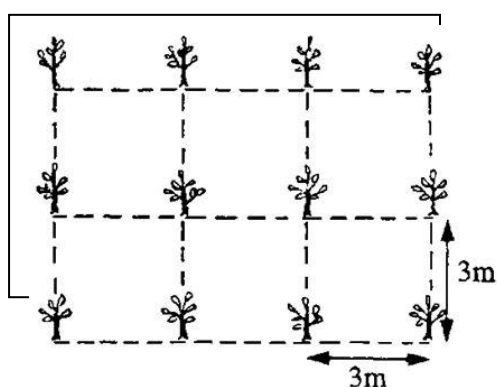
2.2.1 Plot shape

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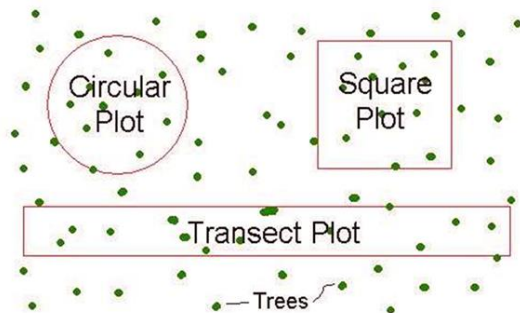
STOCKING RATE (STEMS/*HECTARE*)	PLOT SIZE (*HECTARES*)	RADIUS OF CIRCULAR PLOT (METRES)
100	0.2	25.2
200	0.1	17.8
400	0.05	12.6
500	0.04	11.3
600	0.033	10.2
800	0.025	8.9
1000 +	0.02	8.0

Various plot shapes

2.2.2 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 m^2).
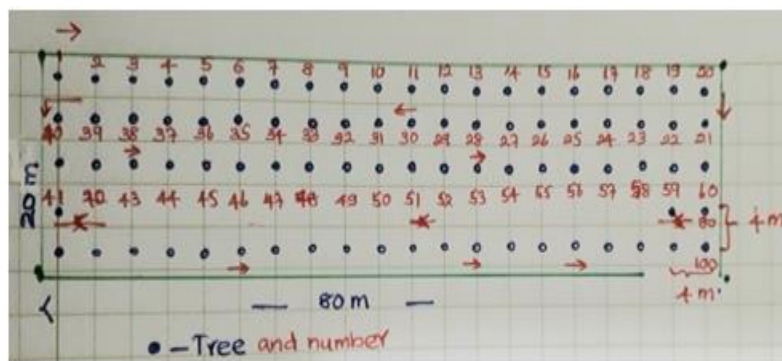
2.3 Basics of mensuration (Tree variables measurement)

(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 diameters 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.

$C = 2 \pi r = d;$

$d = C / \pi$

In this study, Diameter tape is used.

Figure 2: Diameter at breast height (1.3m) is measured by diameter tape. Inventory team follows all the standard and rules recommended in this regard

2.4 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.
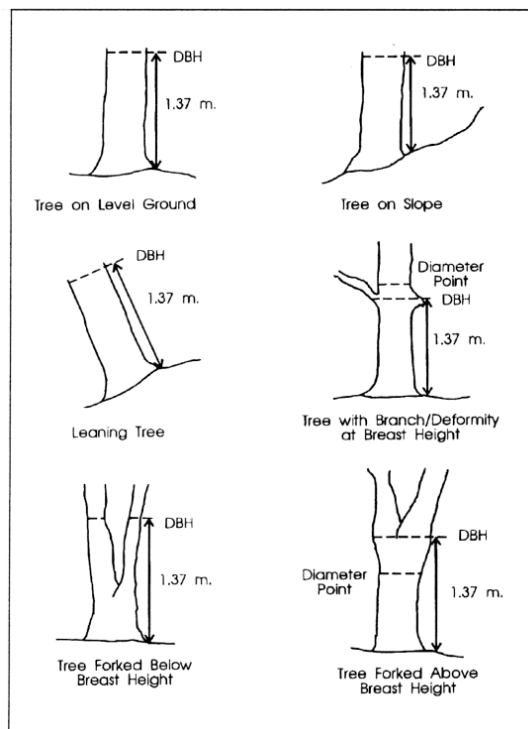
Standard rules governed to measure diameter at breast height

Diameter tape used for the inventory

2.5 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

2.5.1 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 3: Total Tree height was measured by hypsometer and a pole, used instrument of sun unto meter is shown in above

Figure 4: Correct horizontal distance between tree and height observer is being positioned

2.6 General steps for Hypsometer

- 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.

$$\tan \alpha 1 = BC / D$$
$$BC = \tan \alpha 1 \cdot D$$
$$\tan \alpha 2 = AC / D$$
$$AC = \tan \alpha 2 \cdot D$$
$$AB \text{ (height)} = BC + AC$$
$$AB = \tan \alpha 1 \cdot D + \tan \alpha 2 \cdot D$$
$$AB = D (\tan \alpha 1 + \tan \alpha 2)$$
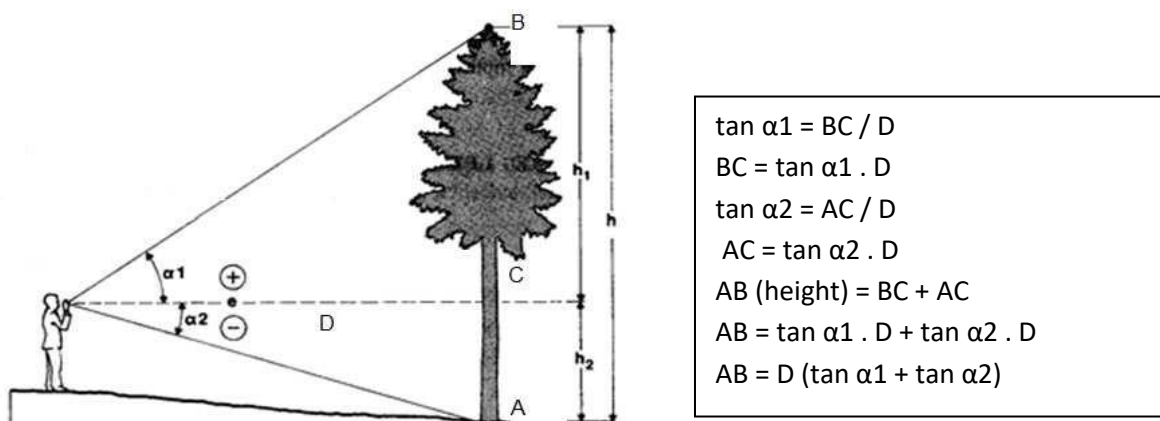
Figure 5: Tree height measurement on a flat terrain

3. Results of inventory of teak plantation-2022

3.1 Teak Plantation of Puttalam

Table 5: Number of trees and tree mean DBH values in plots in Puttalam

Plot number (P)	Block 01		
	No. of trees	Mean DBH (cm)	Mean height (m)
1	88	18.59	16
2	79	18.8	14.5
3	97	17.5	14
4	88	19	14
5	95	18.9	15.3
mean	89(447)	18.5	14.8

Table 6: calculation of tree parameters of Puttalam teak plantation based on, tree height, diameter of mid height of trees, and DBH in order to find form factor, tree actual volume.

Parameters	Puttalum
Total Tree height (m)	14.8
Mean Tree DBH (cm)	18.5
Mean Tree mid diameter	12
Tree form factor	0.461
Actual volume (m3)	0.183
Cylindrical volume (m3)	0.3979

ALL PARAMETERS OF TREE IS WITH BARK

Graph 1: Number of trees against to average DBH range values in Blocks Puttalum

Puttalama
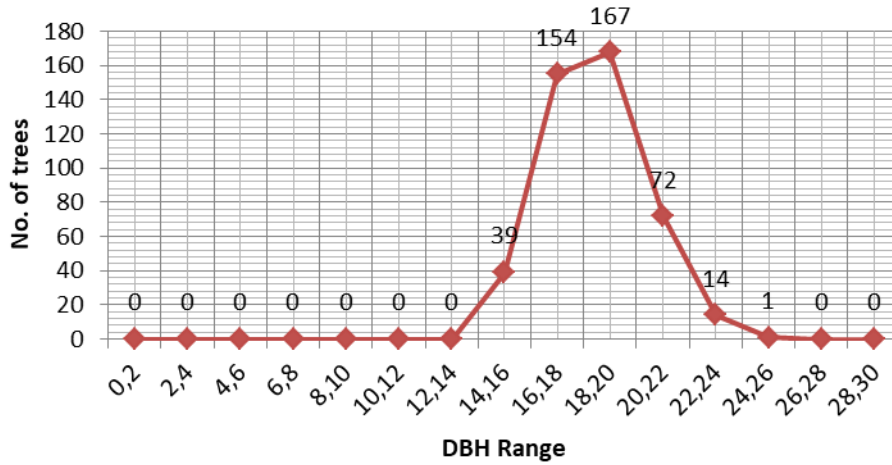
Out of 447 of trees, 254 trees are having more than 16-18.cm dbh. Mean dbh is 18.5cm

It can be assumed that in block no.1. out of 4581 trees, There are 2603 trees having more than 16-18cm DBH category.

Part of puttalum plantation

Tree Height measurement taken by Hypsometer which gives accuracy up to half meter

Figure 6: Sections of Puttalum plantation and how branch pruning scar is recovering , right photo :canopy closing is apparent

Table 7: Estimated number of trees having more than its mean DBH value in Puttalum teak Plantation.

Estate	Block no and its mean dbh value.	No. of trees more than its mean DBH in Block and its %
Puttalum	1 and 18.5 cm	2603 (56%) from 4581 trees

Table .7A		Puttalum block growth parameter with age (planted area app. 8.3 ha from 10ha) Planted year. 2011			
Age (year)	**Measurement taken year**	**Total no. of tree**	**No. of trees per ha**	**DBH (cm)**	**Height (m)**
3	2014	5630	678	4.4	5.1
4	2015	5587	673	8.1	6.1
5	2016	5587	673	10.5	8.0
6	2017	5552	668	12.3	9.0
7	2018	5488	661	12.9	10.4
8	2019	5447	656	15.4	11
9	2020	5093	613	16.37	12.4
10	2021	5050 (before thinning)	608	17.62	12.7
11	2022	4581	551	18.5	14.8

Table 8: Puttalam block growth parameter with age

Puttalam Planted year 2011				MAI and (CAI)	MAI and (CAI)
Age (year)	Measurement taken year	DBH (cm)	Height (m)	For DBH (cm)	For height (m)
3	2014	4.4	5.1	1.46	1.7
4	2015	8.1	6.1	2.03(3.7)	1.52(1)
5	2016	10.5	8.0	2.1(2.4)	1.6(1.9)
6	2017	12.3	9.0	2.05 (1.8)	1.5(1)
7	2018	12.9	10.4	1.84(0.6)	1.48(1.4)
8	2019	15.4	11	2.5 (2.5)	1.37(1.6)
9	2020	16.37	12.4	1.82 (0.97)	1.38(1.4)
10	2021	17.62	12.7	1.76(1.25)	1.27(0.3)
11	2022	18.5	14.8	1.68(0.88)	1.34(2.1)

Table 9: Sample plots information, planted area and tree inventory data and tree thinning information in year 2022 of Puttalum

Estate	Block no.B1	Total trees in block(B1) and sub blocks	Estimated planted area (ha)	No. of Plots	Plots area in block B1 (m2)	Year 2022				Tree Thinning information		
						No. of trees measured for DBH in Block 1 and sub blocks	No of trees for ha.	Average DBH (cm)	Average height approx.(m)	No. of trees thinned	Mean DBH of thinned trees (cm)	Mean Height of thinned trees(m)
Anamaduwa	Sub block 01	863	1.6	5	20x80x5plots	88	550	18.6	16			
	Sub block 02	933	1.7			79	493	18.8	14.5			
	Sub block 03	836	1.5			97	606	17.5	14			
	Sub block 04	1010	1.8			88	550	19	14			
	Sub block 05	939	1.6			95	593	18.9	15.3			
		4581	**8.3**	5	8000	447	558	**18.5**	14.8			

Table 10: Comparison of growth parameter between Puttalum with tree age

Batticaloa all Blocks Planted year 2012.july to 2013 December			Anamaduwa Planted year 2009/2010		Puttalam Planted year 2011	
Age (year)	DBH (cm)	Height (m)	DBH (cm)	Height (cm)	DBH (cm)	Height (m)
3	4.24	3.46	6.6	6	4.4	5.1
4	6.22	4.84	8.2	7.1	8.1	6.1
5	7.42	5.64	10	7.5	10.5	8.0
6	8.87	6.72	11.2	10.3	12.3	9.0
7	9.93	7.57	12.1	11.3	12.9	10.4
8	11.46	9.2	12.4	11.8	15.4	11
9			13.6	12.5	16.37	12.4
10			14.37	13.3	17.62	12.7
11			15.67	14.7	18.5	14.5
12			16	15		

Table 11: Sri Lankan Teak Plantation tree count. Comparison Tree Audit 2021-2022 in Puttalam.

Estate Name	Block number	Geophysics count trees 2021						Geophysics count trees 2022					
		Total good trees	No. of small/poor trees	Reserved trees	Marked for thinning	Total trees	Differences 2021 Vs 2020	Total good trees	No. of small /poor trees	Marked for thinning	Reserved trees	Total trees	Differences 2021vs 2022
Puttalum	B1	4608			442	5050 Before thinning 4608 After thinning	43	4400	Already removed in July 2021		181	4581	469 (27 after thinning)

Table 12: Sample plots information, planted area and tree inventory data in year 2022 of and Puttalam

Estate	Block no.	Total trees in block	Estimated planted area (ha)	No. of Plots	Plots area in block (m2)	Year 2022			
						No. of trees measured for DBH in Block	No of trees for ha.	Average DBH (cm)	Average height appro.(m)
Puttalum	B1	4581	8.3	5	8000 (20x80xx5)	447	551	18.5	14.8

Table 13: Comparison of tree parameters between year 2021 and 2022 in and Puttalum

Estate	Block no.	No. of Plots	Year 2021				Year 2022				
			No. of trees measured for DBH	No of trees for ha.	Average DBH (cm)	Average height(m)	No. of trees measured for DBH	No of trees for ha.	Average DBH (cm)	Average height appro. (m)	Variance in DBH (cm)& Height (-) 2020 vs 2021
Puttalum	B1	5	448	608	17.62	12.7	447	551	18.5	14.7	0.88cm (2.1m)

Table 14: Tree volume and other growth parameters of plantations were estimated based on age of plantation, form factors and inventory data of Puttalum plantation

Tree age or inventory year 2022	AGE OF THE PLANTATION IS 10 years old (planted 2011 April-October AND FORM FACTOR IS ASSUMED AS 0.45							
Block NO.	Total trees	No. of stems/ha	mean height (m)	DBH (cm)	Per Tree volume (m3)	Trees volume m3/ha	Total volume In block (m3)	MAI (m3/ha/year
B1	4581	551	14.8	18.5	0.179	95.8	819	8.7

Table 15: Determination of site index based on growth parameters of past years of Puttalum plantation.

Age of Puttalum plantation is 11 years (Planted year. 2011)

Estate	Block no.	No. of Plots	2013 Aver. DBH (cm)	2014 Ave. DBH (cm)	2015 Ave. DBH (cm)	2016 Ave. DBH (cm)	2017 Ave. DBH (cm)	2018 Ave. DBH (cm)	2019 Ave. DBH (cm)	2020 Aver. DBH(cm)	2021 Aver. DBH (cm)	2022 Aver. DBH (cm)	DBH differences from Year of first measurement to 2021 and (Mean Increment of DBH cm) and periodic increment of DBH{} from First measured year.
Puttalum	B1	5		4.4	8.1	10.5	12.3	12.9	15.4	16.37	17.62	18.5	14.1 (1.68) {2.0}

3.1 Observation, Conclusions and recommendation

I. Sample of Stem canker's area of Teak must be taken with seal plastic storage and culture it for identification of pathogen. After identification of pathogen, then it is easy to find solutions. This can be done first in Batticaloa plantation

II. First thinning of plantation was done in 2021 July by removing unsuitable 442 plus trees. Reasons why thinning is necessary : When excess trees built up canopy and root competition 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 after one to one tree inspection. Thinning regime was decided after estimation of exact age, number of stem /ha, canopy closer, tree inventory data and tree annual rings information. Please see the table 2: thinning regime developed for Puttalam plantation by us.

III. The mean tree volume for ha has increased from 77.9 in 2021 to 95.8 m^3 in 2022, Furthermore it was estimated that this plantation contain of 640.5m^{3}in 2021 and it has increased to 819m3 in 2022.

IV. Results section of this report shows all the necessary information from planting year of this plantation to present audit year. Mean DBH increased and height are 1.7 cm and 1.3 m respectively. Puttalam plantation shows better DBH increased than Anamaduwa Plantation.

V. Around 10 trees have been damaged by lightening.

VI. Number of trees per hectare has reduced from 678 ha within 11 years tree growing period. According to thinning regime, this number can be reduced up to 471 trees per ha.

Finally it can be concluded that teak plantation is healthy and good condition. Plantation is much more potential to get more growth increment particularly for diameter growth for next 9 years if the plantation is maintained and managed scientifically.

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