TEAK TREE INVENTORY AND AUDIT REPORT-2024

CONDUCTED FOR

ASIA TEAK GROUP

AT

Puttalam Teak Plantation
Sri Lanka

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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 was inspected by Mr. J.M.P. Jayalath and me on 2024.3.9 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 measurement of 443 trees was taken from Puttalam plantations.

Puttalum Teak Plantation

Five sample plots having with total sample area of 8640 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 9.6 % of population. In this study, 443 trees were measured for DBH measurement and around 20 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. There are 4569 trees in this plantation in which 443 trees measured for DBH, which represent 9.7% of population.

The inventory result shows that there are 4569 trees (4383 good trees and 186 trees were marked for thinning). The average DBH and Height of trees in the estate is 19.6 cm and 15.5 m respectively. It is found that average trees per ha is 535.   In 2024 audit, it is found that there are 8 trees less than total tree number of 2023 audit which may be dead or uprooted. Details of block wise tree information are shown in table 9).

Analyzing inventory tree data, it is found that more than 25 % of trees are having DBH more than 18-20 cm of mean DBH value for Puttalum plantation that means, out of 4569 trees. There are 1186 trees having more than 18-20cm DBH. Plantation tree DBH distribution results are given in graphs 1, 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 13 years of growth (DBH) data of 2014-2024, mean annual increment of DBH and Height is 1.5 cm and 1.19 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 6). 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 0.21m3. The mean tree volume for ha is 112m3. Furthermore it is estimated that this plantation contain of 959m3. Growth parameters from establishment of the plantation are summarized in table 8.

Finally it can be concluded that Puttalum Teak plantations in Sri Lanka are healthy and good condition.

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
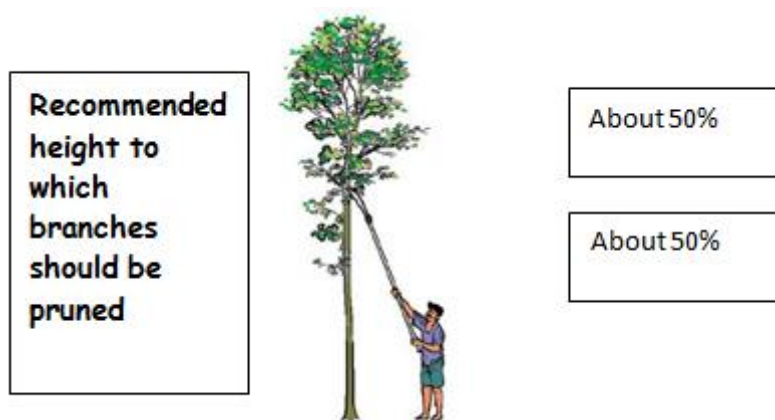
Figure 1: Pruning

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.
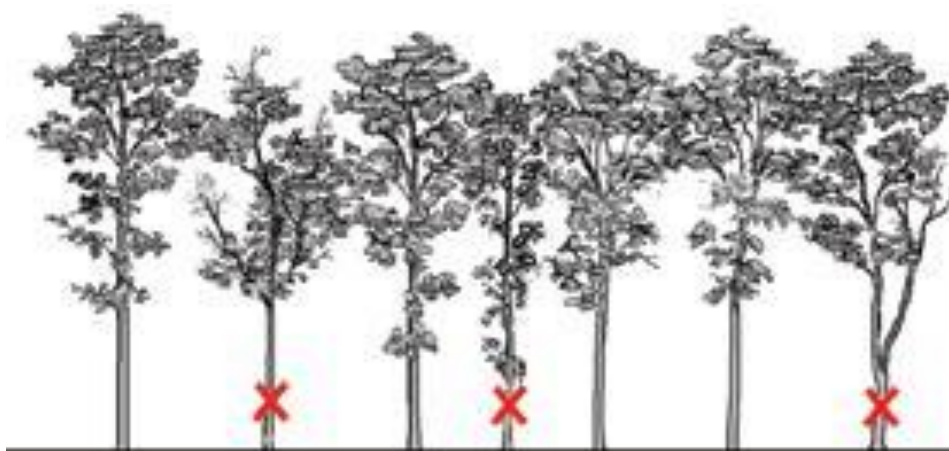
Figure 2: Spacing

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 (8.53 ha)*

Age/ Year	Main crop before thinning					Crop removed				
	Tree No.	Trees / ha	Mean DBH (cm)	Mean Height (m)	Tree Vol. (m^3) or Tree Vol. / ha	Tree No.	Trees / ha	Mean DBH (cm)	Mean Height (m)	Tree Vol. (m^3) or Tree Vol. / (ha)
9/2020	5093	597	16.37	12.4	0.117/69.8					
10/2021	4608	540	17.62	12.7		442+43	56	First thinning		
11/2022	4581	537	18.5	14.8						
12/2023	4577	536	18.8	15	0.187/96					
13/2024	4569	535	19.6	15.5	0.21/112	186	21	Light second thinning		
14/2025	4383	513								
15/2026	4383	513				472	55	Second thinning		
16/2027	3911	458								
17/2028	3911	458								
18/2029	3911	458								
19/2030	3911	458								
20/2031	3911	458	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.

Figure 3: Teak growth curve : (a) DBH against age (b) Total height against age

1.4 Forest Plantation Audit process and Objectives

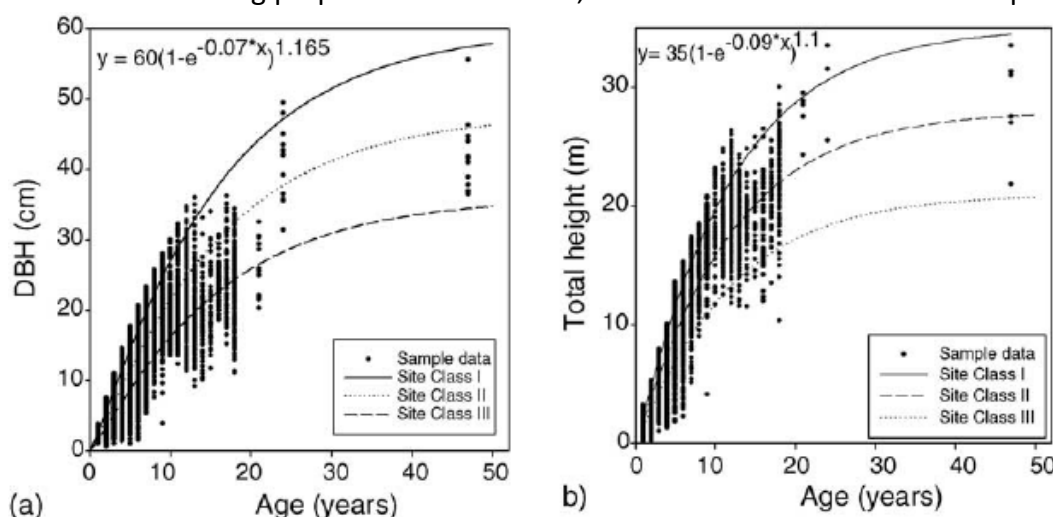Forest Audits generally assess and compliance with the forest management planning manual and the effectiveness of forest management activities in meeting the objectives set out in the forest management plan.

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.

2.1.1 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).
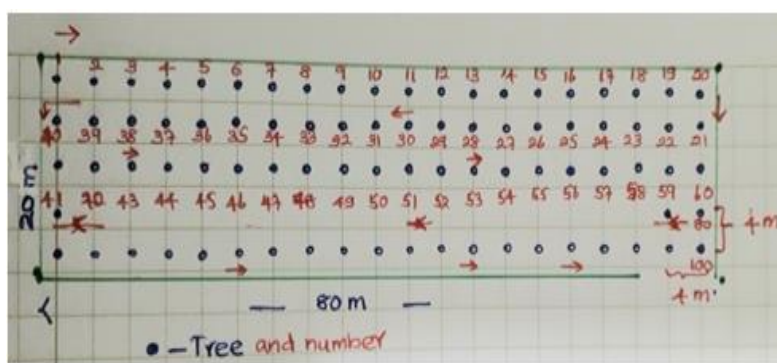
Figure 4:Plot size

2.2 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.

2.2.1 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 5: *Diameter tape used for the inventory*

2.3 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.

2.3.1 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 6*: Total Tree height was measured by hypsometer and a pole, used instrument of sununto meter is shown in above*

3. Results of inventory of teak plantation-2024

3.1Teak Plantation of Puttalam

Table 3: *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	87	19.8	16
2	79	19.5	14.5
3	93	18.7	17
4	89	20.2	16.5
5	95	20.0	13.5
mean	89(443)	19.6	15.5

Table 6. calculation of tree parameters of Puttalum 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)	15.5
Mean Tree DBH (cm)	19.6
Mean Tree mid diameter	12
Tree form factor	0.461
Actual mean tree volume (m3)	0.21
Cylindrical volume (m3)	

ALL PARAMETERS OF TREE IS WITH BARK

Graph 1: *Number of trees against to average DBH range values (cm) in Blocks in Puttalum*
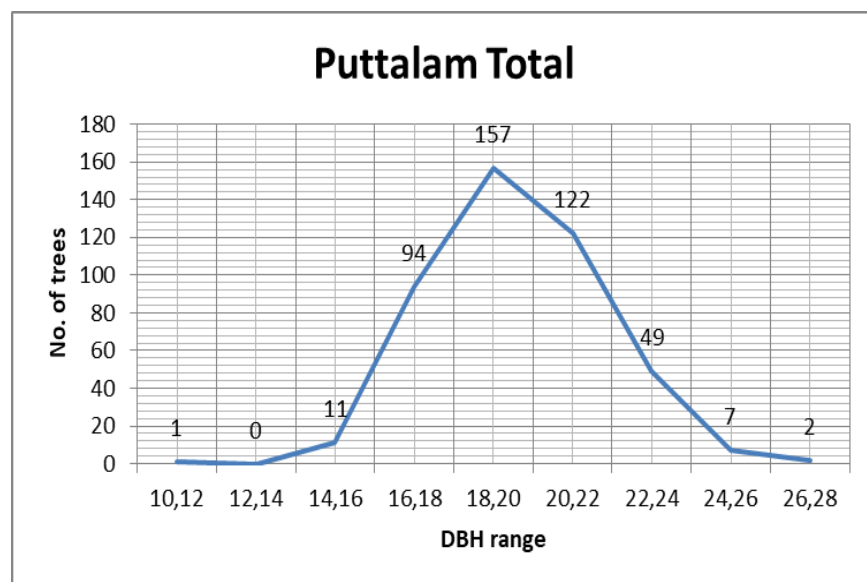
Out of 443 of trees, 115 trees are having more than 18-20 cm dbh. Mean dbh is 19.6cm

It can be assumed that in block no.1. out of 4569 trees, There are 1186 trees having more than 18-20cm DBH category.(25%).

Figure 7: Part of puttalum plantation

Figure 8: Part of teak plantation .Tree Height measurement taken by Hypsometer which gives accuracy up to half meter

Table 4: *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 DBH (18-20 cm) in Block and its %
Puttalum	1 and 19.6 cm	1186(25%) from 4569 trees

Table 5: *Puttalam block growth parameter with age – planted area 8.53 ha*

		Puttalum block growth parameter with age (planted area app. 8.53 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	660	4.4	5.1
4	2015	5587	655	8.1	6.1
5	2016	5587	654	10.5	8.0
6	2017	5552	651	12.3	9.0
7	2018	5488	643	12.9	10.4
8	2019	5447	638	15.4	11
9	2020	5093	597	16.37	12.4
10	2021	4608	540	17.62	12.7
11	2022	4581	537	18.5	14.8
12	2023	4577	536	18.8	15
13	2024	4569	535	19.6	15.5

Table 6: *Puttalam block growth parameter with age – planted year 2011*

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)
12	2023	18.8	15	1,56 (0.3)	1.25 (0.2)
13	2024	19.6	15.5	1.5(0.8)	1.19 (0.5)

Table 7: *Sample plots information, planted area and tree inventory data and tree thinning information in year 2024 of Puttalum*

Estate	Block no.B1	Total trees in sub block(B1)and blocks	Estimated planted area (ha)	No. of Plots	Plots area in block B1 (m2)	Tree Thinning information		
						No. of trees thinned	Mean DBH of thinned trees (cm)	Mean Height of thinned trees(m)
Anamaduwa	Sub block 01	857	1.6	(20x92) 1840m2	20x80x5 plots	51		
	Sub block 02	930	1.7	1680m2 (20x84)		35		
	Sub block 03	835	1.5	1760m2 (20x80)		32		
	Sub block 04	1009	1.8	1600m2 (20x80)		38		
	Sub block 05	938	1.6	1760m2 (20x80)		30		
		4569	**8.3**	5	8640	**186**		

Estimated planted area was considered earlier 8.53 ha instead of 8.3ha. Actual total number of trees was counted as 4569

Table 8: *Sri Lankan Teak Plantation tree count.Comparison Tree Audit 2023-2024 in Puttalam*

Estate Name	Block number	Geophysics count trees 2023						Geophysics count trees 2024					
		Total good trees	No.of small/poor trees	Reserved trees	Marked for thinning	Total trees	Differences 2022vs 2023	Total good trees	No.of small /poor trees	Marked for thinning	Reserved trees	Total trees	Differences 2023vs 2024
Puttalum	**B1**	4396	Already removed in july 2021	181		4577	4	4383	Already removed in july 2021	186		4569	8

Table 9: *Sample plots information, planted area and tree inventory data in year 2024 of and Puttalam*

Estate	Block no.	Total trees in block	Estimated planted area (ha)	No. of Plots	Plots area in block (m2)	Year 2024			
						No. of trees measured for DBH in Block	No of trees for ha.	Average DBH (cm)	Average height appro.(m)
Puttalum	B1	4569	8.3 (8.53ha)	5	8640	443	535	19.6	15.5

Table 10: *Comparison of tree parameters between year 2023 and 2024 in and Puttalum*

	Block no.	No. of Plots	Year 2023				Year 2024				
			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 (-) 2023 vs 2024
Estate / Puttalum	B1	5	445	536	18.5	15	443	535	19.6	15.5	0.6cm(0.5 m)

Table 11: *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 2024	AGE OF THE PLANTATION IS 13 years old (planted 2011 April-October AND FORM FACTOR IS ASSUMED AS 0.45							
Block N0.	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	4569	535	15.5	19.6	0.210	112	959	8.6

Table 12:*Determination of site index based on growth parameters of past years of Puttalum plantation*

Age of Puttalum plantation is 13 years (Planted year. 2011)

Estate	Block no.	No. of Plots	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)	2023	2024	DBH differences from Year of first measurement to 2021 and (Mean Increment of DBH cm) and periodic increment of DBH{} from First measured year.
Puttalam	B 1	5	4.4	8.1	10.5	12.3	12.9	15.4	16.37	17.62	18.5	18.8	19.6	15.2 (1.5) {1.52}

4. Observation, Conclusions and recommendation

I. The mean tree volume for ha has increased from 96 in 2023 to 112 m³ in 2024, Furthermore it was estimated that this plantation contain of 855 m³in 2023 and it has increased to 959 m3 in 2024.

II. Results section of this report shows all the necessary information from planting year of this plantation to present audit year.

Finally it can be concluded that both teak plantation are healthy and good condition. Plantation is much more potential to get more growth increment particularly for diameter growth for next 8 years if the plantation is maintained and managed scientifically. Number of trees per ha will have to be reduced for that success. In year 2024, we marked 186 trees for thinning as light second thinning.

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