TEAK TREE INVENTORY AND AUDIT REPORT-2022

CONDUCTED FOR

ASIA TEAK GROUP

AT

Anamaduwa Teak Plantation

Sri Lanka

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Executive summary

Anamaduwa Teak plantations is one of three 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 261 trees were taken from Anamaduwa plantation by mean of four sample plots.

Anamaduwa Teak Plantation

Four sample plots having with total sample area of 3600 m2 have been permanently setup in different locations in Anamaduwa plantation. It is found by this study that total estimated planted area is 4.18ha (out of 4.8ha) and sample plots represent 8.6 % of population. In this study, 261 trees were measured for DBH measurement and around 40 trees for height measurement taken by hypsometer and pole. We applied all the international standards when measuring the tree parameters such as DBH and Height. (See page 14-17). There are 3010 trees in this plantation in which 261 trees measured for DBH, which represent 8.6% of population.

The inventory results show that there are 3010 trees (2925 good trees and 85 for reserved trees). The average DBH and Height of trees in the estate is 16 cm and 15.58 m respectively. It is found that average trees per ha is 720. In 2022 tree count audit, out of 3010 total trees, there were 2925 good trees and 85 reserved trees. In 2022 audit it is found that 636 trees from total tree number are less than 2021 audit figures which may be mainly thinned out or rarely uprooted. Details of block wise tree information are shown in table 3.1 and 3.9.

Analyzing inventory tree data, it is found that more than 46 % of trees are having DBH more than 14.-16 cm of mean DBH value for Anamaduwa plantation that means, out of 3010 trees. There are 1407 trees having more than 14-16cm DBH. Plantation results are given in graphs, see page 20. Growth parameters from establishment of the plantation are summarized in table 3.6-3.8.These findings can be used for future planning of thinning and final mode of harvest.

After analyzing the last 12 years of growth and DBH data of 2013-2022, mean annual increment of DBH and Height is 1.33 cm and 1.29 m respectively. This site growth parameters are useful to find out suitable or complying 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 3.8 page 25). The 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 mean volume per tree of Anamaduwa was found as 0.141m^3. The mean tree volume for ha is 101 m^3. Furthermore it is estimated that this plantation contain of 424m^3. Growth parameters from establishment of the plantation are summarized in table 3.3. 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). The yield table intended to prepare, will solve this question.

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 plantation at end of felling rotation.

Finally it can be concluded that this teak plantation are healthy and good condition. There are much more potential to get more growth increment particularly for tree stem diameter for next 8 years if the plantation is maintained and managed scientifically.

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

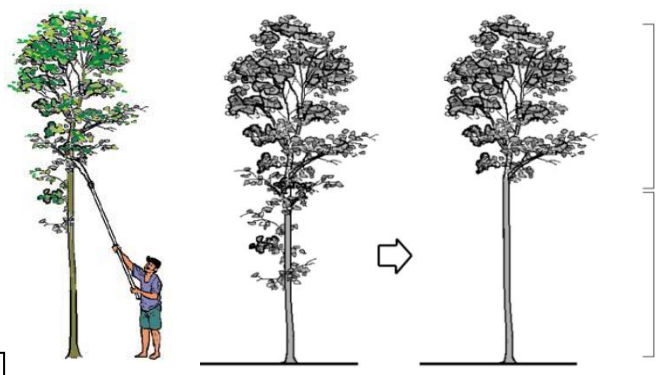
Fluting (irregular involutions and swellings) in the teak stem has been observed in a number of plantations in tropical countries. In some study, the mean heritability value of stem straightness was found to be 0.83, indicating that the character for stem straightness is strongly controlled by provenance 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



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) (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

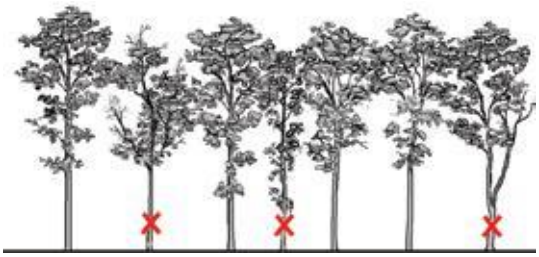


Table 2: Thinning regime developed for Anamaduwa plantation based on planted area 4.18ha

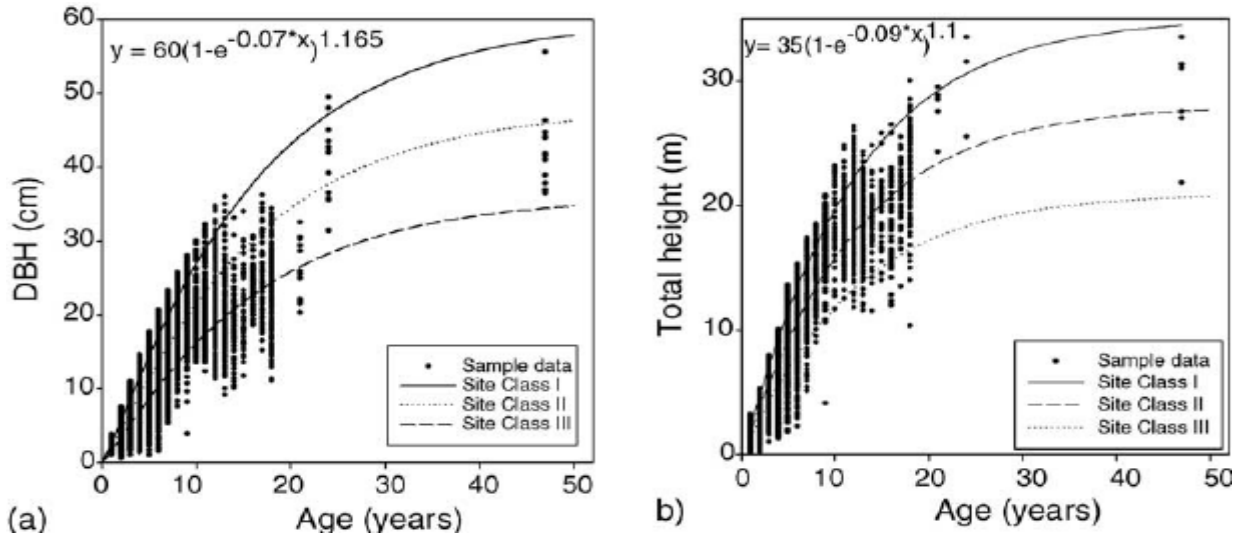
Age/ Year	Main crop before thinning					Crop removed				
	Tree No.	Trees / ha	Mean DBH (cm)	Mean Height (m)	Tree Vol. (m^3) or Tree Vol. / ha	Tree No.	Trees / ha	Mean DBH (cm)	Mean Height (m)	Tree Vol. (m^3) or Tree Vol. / (ha)
10/ 2020	3683	881	14.37	13.3	0.094/844					
11/ 2021	3683	881				673	161	First Thinning		
12/ 2022	3010	720								
13/ 2023	3010	720								
14/ 2024	3010	720								
15/ 2025	3010	720								
16/ 2026	3010	720				518	123	Second Thinning		
17/ 2027	2492	607								
18/ 2028	2492	607								
19/ 2029	2492	607								
20/ 2030	2492	607						Final felling		

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 Puttalam 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 (m^3/ha/yr)	CIA (m^3/ha/yr)
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 andstrength (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. 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, 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.

Inventory team

Figure 2.1. Plot number and one corner post of square shape plot in Anamaduwa estate belong to Asia Teak.

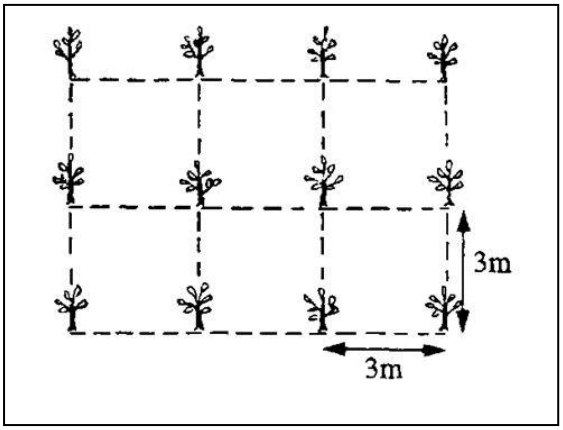
2.2. System of Planting

Square system:

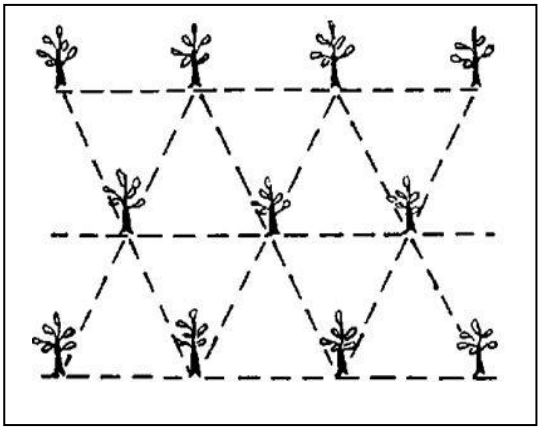
This system is considered to be the simplest of all the system and is adopted widely. Under this system, intercultural operations, spraying, harvesting etc., can be done conveniently and easily and irrigation can be done in two directions.

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.



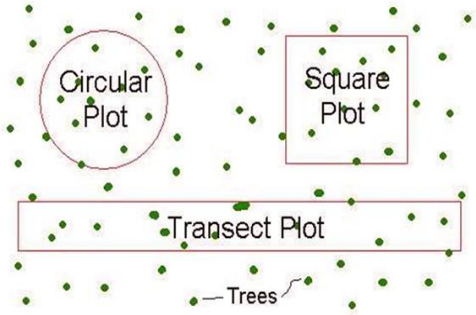
Square system



Triangular system

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.



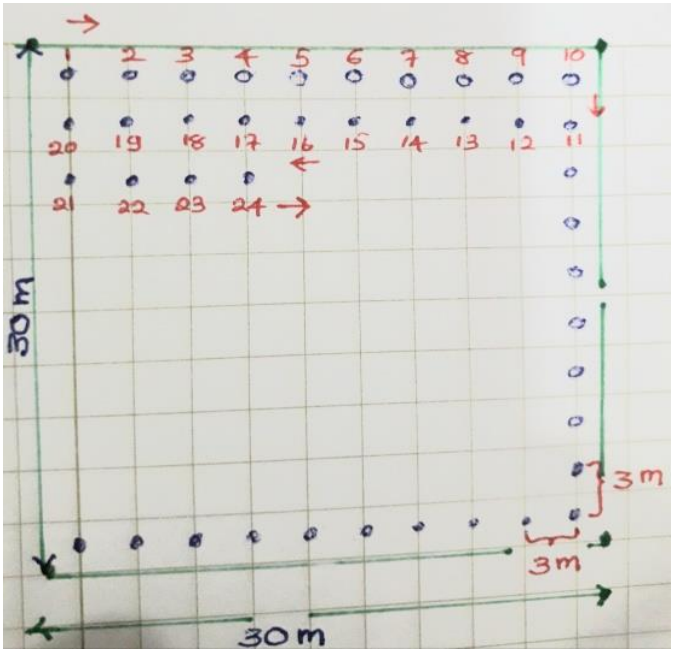
STOCKING RATE (STEMS/*HECTARE*)	PLOT SIZE (*HECTARES*)	RADIUS OF CIRCULAR PLOT (METRES)
100	0.2	25.2
200	0.1	17.8
400	0.05	12.6
500	0.04	11.3
600	0.033	10.2
800	0.025	8.9
1000 +	0.02	8.0

Various plot shapes

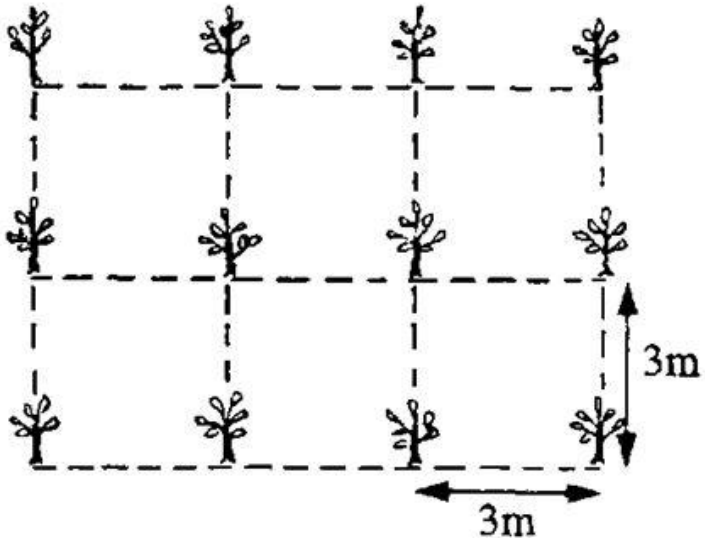
2.2.2. Plot size and planting system of Sri Lankan Asia Teak Plantation

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

All the plots of Anamaduwa are 30m x 30m (900 m²)



10 trees from vertical and horizontal rows were included to plot area. Tree spacing is 3m x 3m



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.

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

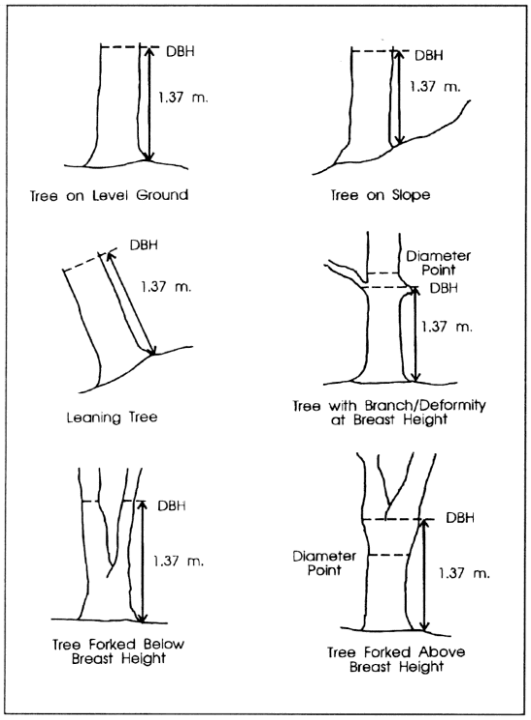
$$d = C/ \pi$$

In this study, Diameter tape is used

Figure 2.2. Diameter at breast height (1.3m) is measured by diameter tape. (left Anamaduwa- Right Puttalama). 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

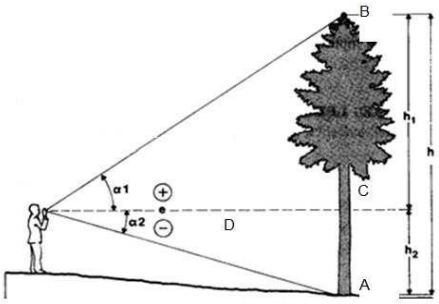
There are two methods, one is direct method which involves using height measuring rods only for small trees (see right). Other method we used is trigonometric principles. Sunto hypsometer used as instrument for this purpose

Figure 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

2.6. 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



tan α1 = BC / D
BC = tan α1 . D
tan α2 = AC / D
AC = tan α2 . D
AB (height) = BC + AC
AB = tan α1 . D + tan α2 . D

Figure 2.5: Tree height measurement on a flat terrain

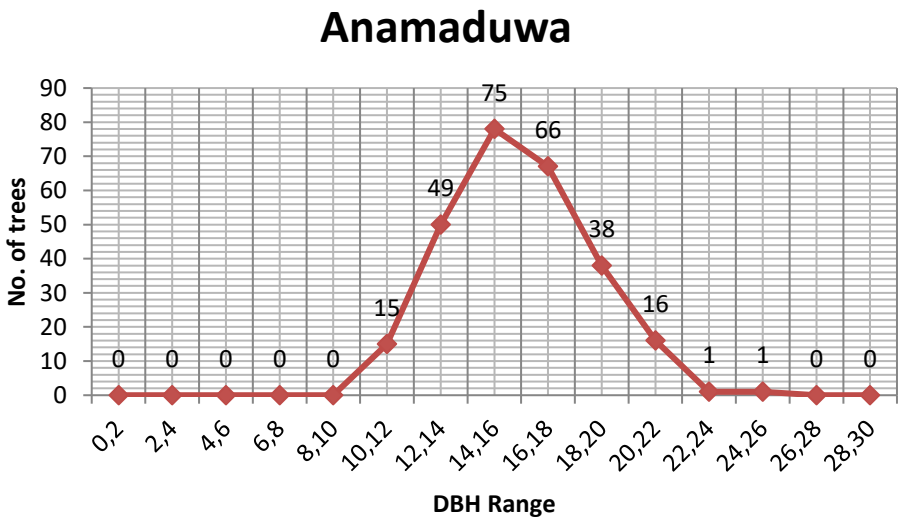
3. Results of inventory of teak plantation

3.1. Teak Plantation of Anamaduwa

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

Plot number (P)			Block 01	
	No. of trees	Mean DBH (cm)	DBH range (Max. and Mini) cm	Mean Height (m)
1	65	18.5	Min 14.7 to max 25.3	17
2	66	15.5	Min 11 to max 21	16
3	64	15	Min 11 to max 20.8	15
4	66	15	Min 11 to max 22	14
mean	**65 (total 261)**	**16**		**15.58**

Graph 3.1. Number of trees against to average DBH range values in Blocks in Anamaduwa



Out of 261 of trees, 122 trees are having more than 14 - 16cm dbh. (Mean value is 16 cm)

It can be assumed that in block no.1. Out of 3010 trees, There are 1407 trees having more than 14-16 cm DBH category.

Estate	Block no and its mean dbh value.	No. of trees more than its (14-16cm) mean DBH in Block 1 and its %
Anamaduwa	1 and 16 cm	1407 (46%) from 3010 trees

Figure 3.1. Different part of view of Anamaduwa plantation

View of Plantation

Preparation for forest inventory with the hypsometer and other instruments

Tree height measurements is being taken by Hypsometer

Compost fertilizer application for soil improvement was started and completed at first quarter of this year.

Table 3.2. Growth parameters and growth rate of Annamaduwa teak plantation based on mean data of samples plots taken

		Anamaduwa (planted area app. 4.18 ha from 4.8ha) Planted year. 2009/2010			
Age (year)	Measurement Taken year	Total no. of tree	No. of trees per ha	DBH (cm)	Height (m)
3	2013			6.6	6
4	2014	4521	1081	8.2	7.1
5	2015	4464	1068	10	7.5
6	2016	4514	1079	11.2	10.3
7	2017	4462	1067	12.1	11.3
8	2018	4264	1020	12.4	11.8
9	2019	4036	965	13.6	12.5
10	2020	3683	881	14.37	13.3
11	2021	3646 (before thinning)	872	15.67	14.68
12	2022	3010	720	16	15

Table 3.3. Anamaduwa block growth parameter with age

Anamaduwa Planted year 2009/2010				MAI and (CAI)	MAI and (CAI)
Age (year)	Measurement taken year	DBH(cm)	Height (m)	For DBH (cm)	For height (m)
3	2013	6.6	6	2.2	2
4	2014	8.2	7.1	2.05(1.1)	1.77(1.6)
5	2015	10	7.5	2 (0.4)	1.5 (1.8)
6	2016	11.2	10.3	1.86(1.2)	1.72(2.8)
7	2017	12.1	11.3	1.73(0.9)	1.61(1)
8	2018	12.4	11.8	1.55(0.3)	1.47(0.5)
9	2019	13.6	12.5	1.51(1.2)	1.51(0.7)
10	2020	14.37	13.3	1.43(0.77)	1.44(0.8)
11	2021	15.67	14.68	1.42 (1.3)	1.33 (1.38)
12	2022	16	15	1.33 (0.33)	1.25 (0.32)

Table 3.4. Comparison of growth parameter between Batticaloa, Anamaduwa and Puttalum with tree age

Batticaloaall 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	10	7.86	12.4	11.8	15.4	11
9	11.34	8.3	13.6	12.5	16.37	12.4
10			14.37	13.3	17.62	12.7
11			15.67	14.68	18.5	14.8
12			16	15		

Table 3.5. Sri Lankan Teak Plantation tree count. Comparison Tree Audit 2021-2022 in Anamaduwa

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 2020 vs 2021	Total good trees	No.of small /poor trees	Marked for thinning	Reserved trees	Total trees	Differences 2021 vs 2022
Anamaduwa	B1	3017			629	3646 (before thinning 3017 (after thinning)	37	2925		Already removed in April 2021	85	3010	636

Table 3.6. Sample plots information, planted area and tree inventory data and tree thinning information in year 2022 of Anamaduwa

Estate	Block no	Total trees in block(B1)	Estimated planted area (ha)	No. of Plots	Plots area in block B1 (m^2)	Year 2022						
						No. of trees measured for DBH in Block of sub blocks	No of trees for ha.	Average DBH (cm)	Average height approx.(m)	Tree Thinning information		
										No. of trees thinned	Mean DBH of thinned trees (cm)	Mean Height of thinned trees(m)
Anamaduwa	Sub Block 1	549	0.6	4	3600 (900x4)							
	Sub Block 2	660	1									
	Sub Block 3	677	1									
	Sub Block 4	725	1									
	Sub Block 5	399	0.5									
		3010	4.18	4	3600	261	720	16	15.58			

**** In future forest inventory, one new plot will be introduced into Block 03 which is not covered in present 4 plots

Table 3.7 Comparison of tree parameters between year 2021 and 2022 in Anamaduwa

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 approx.(m)	Variance in DBH (cm) & Height (-) 2022vs 2021
Anamaduwa	B1	4	263	721 Before thinning 872 After thinning	15.67	14.6	261	720	16	15.58	0.33 cm (1.4m)

Table 3.8.Tree volume and other growth parameters of plantations were estimated based on age of plantation, form factors and inventory data of Anamaduwa plantation

Tree age or inventory year 2022		AGE OF THE PLANTATION IS 12 YEARS OLD Planted year 2009/2010 AND FORM FACTORIS 0.45						
Block N0.	Total trees	No. of stems/ha	DBH (cm)	Height (m)	Per Tree volume (m3)	Trees volume m3/ha	Total volume in block (m^3)	MAI (m^3/ha/year)
B1	3010	720	16	15.58	0.141	101	424	8.45

Table 3.9.Determination of site index based on growth parameters (DBH) of past years of Anamaduwa plantation

Annamaduwa, 12 years old (Annamaduwa, planted 2009 October)

Estate	Block No	No. of Plots	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	DBH differences from Year of First Measurements to 2022 and (Mean Increment of DBH cm) and periodic increment of DBH {} from First measured year.
Anamaduwa	B1	4	6.6	8.2	10	11.2	12.1	12.4	13.6	14.37	15.67	16	9.4 (1.33) {1.6}

4.1 Observation, Conclusions and Recommendation

(1) First thinning of plantation was done in 2021 April by removing unsuitable 629 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 Anamaduwa plantation by us. (Page 8)

(2) As recommended in 2021, Application of soil improvement method and soil erosion prevention methods had been applied as given instruction such as “It is recommended to apply these cow dung or compost 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”

(3) The effectiveness of fertilizing must be closely monitored if results are not up to expectations. Review of composition of fertilizer is recommended.

(4) Root system of Uprooted trees should be closely monitored at regular basis if termite causes or help for decaying of roots. Around 10 trees have been damaged by lightening.

(5) 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.

(6) The mean tree volume for ha has increased from 91 in 2021 to 101 m^3 in 2022, Furthermore it was estimated that this plantation contain of 381m^3in 2021 and it has increased to 424m3 in 2022.

(7) Results section of this report shows all the necessary information from planting year of this plantation to present audit year. Mean DBH increment and height are 1.33 cm and 1.3 m respectively.

(8) Number of trees having more than 14-16 cm DBH values have increased from 1261 in 2021 to 1407 in 2022.

(9) Number of trees per ha has reduced from 1081 ha to 720 tree per ha during the period of 12 years growing of trees. According to thinning regime, this number can be reduced upto 607 per ha.

The Silvicultural treatments have been applied timely and it is observed that after analyzing the plantation tree growth parameters, this teak plantation is 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 by silvicultural treatments timely and managed the plantation scientifically.

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