## PROJECT PROPOSAL

# PROPOSED THINING REGIME PLAN FOR PALUAHAYAYA TEAK PLANTATION IN ANAMADUWA SRI LANKA

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## PROJECT ABSTRACT

**Title:** Proposed Thining Regime Plan for Anamaduwa Teak Plantation

**Executive Summary:**

Teak has the highest trade demand among hardwood species in Sri Lanka due to its mellow color, physical and mechanical properties as well as high capacity in durability. In Sri Lanka, smallholder teak plantations are playing an important role in the supply of tropical timber for the day by day increasing demand. To make best production it is fruitful in practicing thinning in the plantation for acquiring high economical and environmental benefits. This project is followed up by the Asia Tropical Plantations to prepare thinning regime plan based on forest inventory information by analyzing and evaluating of growth parameters and other information of teak trees in three teak plantations viz. Anamaduwa, Puttalam and Batticoloa. Among those, Anamaduwa Plantation is consisting 3600 $m^2$ of sampling area existing with four plots. The studied area posses with 4.18 ha with having total number of 3683 trees. Among them 3576 were in good condition 11 in small or poor in growth and 96 were reserved trees. 14.38cm of average DBH was estimated within 322trees as well as average height was 13.3 m within 25 trees. 894 trees were estimated per hectare. Total volume of production was 346.2 $m^3$. As the estimated volumes, 0.094$m^3$ of volume was represented per tree while 84.4 $m^3$ represented per hectare. However the mean annual increment of DBH was 1.43cm and the mean annual increment of height was 1.44 m. According to the proposed thinning regime it is estimated that 155/ha trees can be removed in 2021 from $11^{th}$ aged Anamaduwa teak plantation and as the second thinning it can be removed 135/ha trees in 2026. However before implementing thinning; erosion prevention methods must be applied, concrete posts at corner of sample plot need to be reestablished, trees to be removed should be identified, marked and numbered, fire lines must be properly maintained and trees should be closely monitored for getting the maximum benefit against to the investment.

| | |
|---|---|
| **Field** | **:** Teak Plantation Management |
| **Executing Agency** | **:** Asia Teak Tropical Plantation |
| **Approving Institute** | **:** |
| **Duration** | **:** |
| **Commencing Date** | **:** |
| **Allocated Budget** | **:** |
| **Proposed Source of Finance** | **:** |

# CONTENT

## CONTEXT

Teak plantations are widely established throughout the tropics in the world. It was introduced to Sri Lanka in 1680s. Since 1960s Sri Lanka established teak plantations with the aim of producing quality timber which has an immense validity on plantation industry due to its attractive mallow color, superior physical as well as mechanical properties and high durability. Due to its attractive colour and grain, durability, lightness with strength, ease of seasoning without splitting and cracking, ease of working and carving, resistance to termite, fungus, and weathering, the demand for the timber is increased.

Teak grows well in regions having deep, flat and well-drained alluvial soils rich in calcium, a mean annual temperature of 22-27°C and annual precipitation of 1,200-2,500 mm, with a marked dry season of maximum 50 mm of rain. Dry site conditions are usually associated with stunted growth. Highly moist condition may be conducive for faster growth, but with more sapwood, lower average density, yellowish colour, poor texture and inadequate strength.

In Asia, teak is grown in rotations of 60 years or more while in tropical America plantations are harvested at 20 to 30 years. Teak trees grown in plantations on good soils may reach an average of 60 cm diameter at breast height (dbh), and 30 m in height in about 50 years. Many factors such as site selection, seed supply and seed quality, management practices and other biological factors such as insects affects directly to the plant growth and the final harvesting volume. Substantial progress has been accomplished in the establishment and management of teak plantation. Nevertheless, it is necessary to fully adopt modern management techniques to increase the productivity of existing and new plantations to ensure the supply of high quality timber to satisfy the increasing demand from the markets.

Site selection is the most critical issue for successful management factor of teak plantation. The concept of site includes the set of biotic and abiotic factors that influence tree growth. Teak is native to regions of South Asia with a monsoon climate. It develops on fertile soils of alluvial, limestone, and basalt origin (Kaosa-ard, 1989).

In this proposed project plantation is located in Anamaduwa area in Sri Lanka which belongs to the dry zone having following climatic conditions and soil properties as shown Table 1. It consist of 3600$m^2$ of sampling area which was belongs to 4.8 hectare. It covered 7.5% of population of the site. It consist with 3683 trees which including 3576 good trees, 11 small and poor trees and 96 reserved trees. The topographical, geographical and the climatic conditions were definitely affected for the growth rate of the existing population of the plantation. For this site the following properties may be helpful to produce 346.2 $m^3$ of timber as estimated in this study. Mean volume per tree of Anamaduwa area was 0.094$m^3$ while it produced 84.4 $m^3$ volumes per hectare in that site.

*Table 1: Anamaduwa site requirements of teak plantation*

| Anamaduwa site requirements for the established teak plantation | |
|---|---|
| **Climatic/topographic** | |
| **Site factor** | **Optimum condition** |
| Altitude | 0-900 m |
| Temperature | 21-32 °C |
| Precipitation | 55-1195 |
| Seasonality | dry season |
| Slope | 0-5% |
| Topography | Flat, undulated |
| **Soil properties** | |
| **Site factor** | **Optimum condition** |
| Soil origin | Alluvial, Basaltic, Limestone, Sandstone, Quartzite |
| Texture | Loamy medium texture |
| Depth | Depth (90 cm- 2m) |
| Water holding capacity | Good |
| Compaction | Non compacted |
| Bulk density | Low |
| Drainage | Good |


*Figure 1: Location of Anamaduwa plantation shared by the GPS*

Due to immediate cash needs, plantations are very often harvested prematurely, before trees reach optimum diameters and value per volume and also sometimes they harvest the plantation in very late ages when the plantation gets over-matured stage. Both stages are not suitable for harvesting because it doesn't gain maximum production. Therefore silvicultural management applied for a plantation in correct way using appropriate techniques is very essential task. Site matching, pruning, spacing, thinning methods, rotation age and harvesting have been refined, yet the productivity of plantations is low and is declining steadily in successive rotations. Rotation length (harvesting age) is decided by concerning the species, age, site quality, growth rate, thining methods, thining cost, harvesting cost and the investment.

Key elements for the proper development of the teak trees are well-timed thinning and pruning. Pruning refers to the cutting of the side branches off the main trunk of the trees while they are growing in order to ensure straight and high-quality logs. Meanwhile thinning refers to when some of the underperforming trees in the plantation are cut and sold prematurely, thus allowing the best trees to continue developing fully with more space and soil nutrients. 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.

Teak is a light demanding species and its growth and development is reduced sharply under poor light conditions. Hence, spacing as well as intensive weeding is very necessary during early establishment of the plantation. Initial spacing of teak plantation varies (1.8×1.8 to 4×4 m) depending on many factors as site quality, cost of establishment, thinning regime, small woodutilization, planting system, e.g. agro-forestry, intercropping etc. However, site quality seems to be the priority factor directing the size of spacing in the teak planting programme.

Mainly the purpose of thinning is to increase economic gain. The gain may be achieved by offsetting the expense of carrying establishment costs to rotation age, increasing the value of the product, and increasing stands utilization. Although thinning is primarily aimed at improving the value of the residual stems, other benefits now being recognized are risk reduction for insect infestations, disease epidemics, and damage from abiotic agents. The mechanics by which thinning reduces theserisks is not fully understood.

Thinning prescriptions vary from one locality to another. It is often governed by revenue rather than silvicultural considerations. In a good quality plantation, managed on a 50 year rotation, the thinning is carried out at the fourth, eighth, 12th, 18th, 26th and 35th years. Thinning schedule varies with site quality. In better plantations the thinning are done early as compared to poor plantations. The first thinning is conducted at 5-10 years after planting, depending on site quality and the size of initial spacing. Generally, under good site and close spacing (1.8×1.8 m and 2×2 m) the first and second thinning (mechanical thinning) are conducted at 5 and 10 years respectively. About 25% of the stock is left for further growth and development after the second thinning.

Alternate diagonals in the first thinning, and alternate rows in the next are thinned in second thinning. If properly done, thinning can result in increased growth rates and improved resistance to pest attack. However, if there is considerable disturbance, there can be initial severe damage to the site, reduced growth in residual trees, and increased susceptibility to pest attack. 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 epitomic 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 epitomic shoots.

Thinning is done in two ways as systematic thinning and selective thinning. In systematic thinning, trees are removed according to a predetermined system, without considering the merits of individual trees. There are two main approaches to selecting the trees to be removed in any thinning, negative selection and positive selection. In negative selection, suppressed and poorly formed trees are removed without considering the growth of remaining trees. Only undesirable trees are removed, thus improving the overall quality of the stand. Undesirable trees include wolf trees, whips and badly shaped trees such as forked, bent and heavily branched individuals, damagedand diseased trees, trees of low increment or low value, and unwanted species. But in positive selection, competing trees are removed to maximize the growth of the 'best' trees. The best trees of the stand are identified and their growth and development is actively promoted by removing competitors. This approach is usually associated with crown thinning, where management is focused on a selected number of trees which will eventually form the final crop. Selective thining methodology was applied for the Anamaduwa Teak Plantation

Therefore spacing of trees and the type of thinning, timing of thinning or thinning cycle and intensity of thinning strongly influence to the pattern of growth as well as the yield of the plantation.There are two main types of thinning: low and crown thinning. Thinning intensity is a description of how many trees, how much basal area or how much volume will be removed from the stand. Thinning cycle is the interval in years between successive thinning.

Usually management objectives are achieved by applying a series of thinning (*thinning regime*). A thinning regime describes when thinning will start and end and the plan for each intervention in terms of type, intensity and cycle. When designing a thinning regime, it should be concerned on each species follows a characteristic growth pattern which will influence for the thinning regime. Site quality is also should be concerned which is usually expressed as Yield Class. Yield class is an index used in potential productivity of even-aged stands of trees, which is based on the maximum mean annual increment of cumulative timber volume achieved by a given tree species growing on a given site and managed according to a standard management prescription. Long-term management objectives also affect to the thinning regime. Therefore it should be concerned when proposing thinning regime.

***Table 2: Growth parameters of Teak governed by site quality of some other countries.***

| Site q ıality 19 | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Age** | No. of stems (ha) | Top height (m) | DBH (cm) | Per Tree volume (m3) | Trees volume (ha) | MAI (m3/ha/yr) | CIA (m3/ha/yr) |
| **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 3: Growth parameters of Teak governed by site quality of some other countries.***

| Site q ıality 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 |

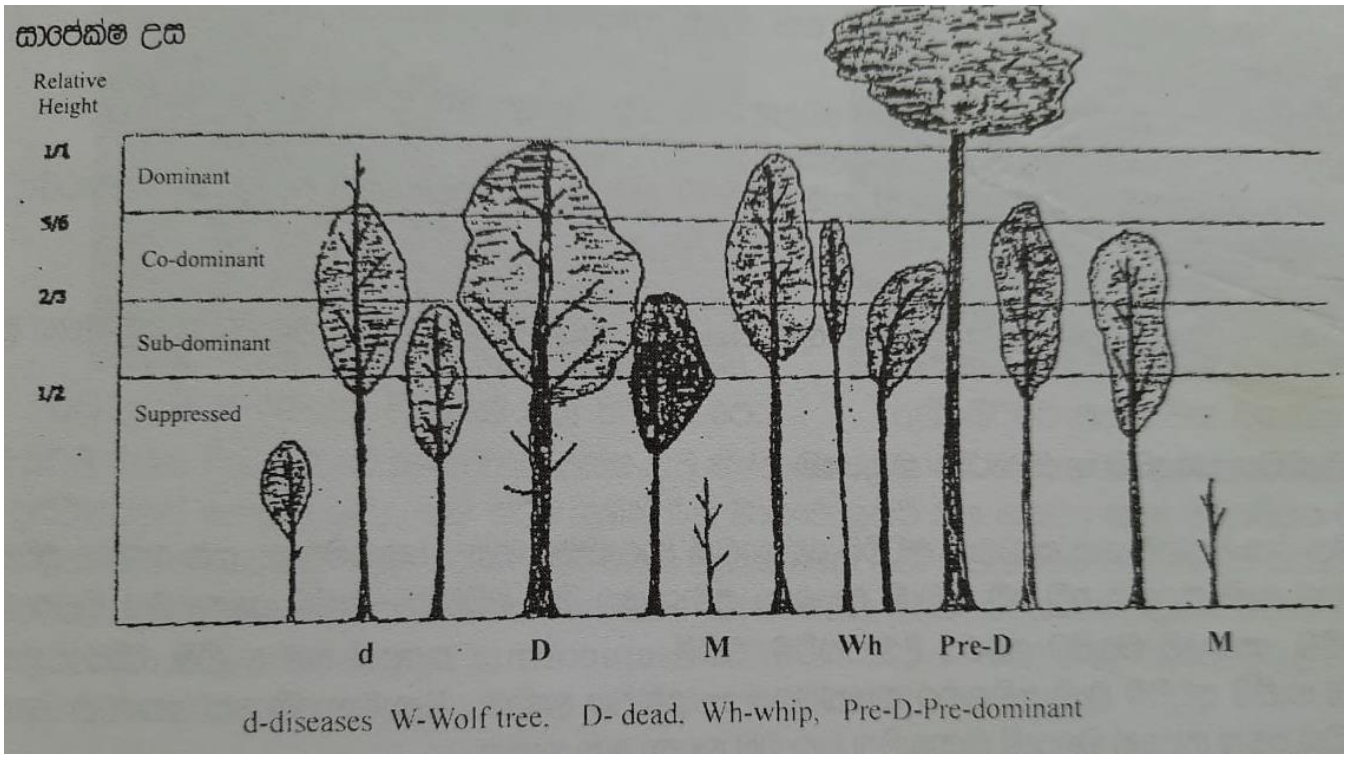



Figure showing unwanted trees to be removed from plantation

## 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.

### ULTIMATE OBJECTIVE

- PREPARING THINING REGIME FOR THE ANAMADUWA TEAK PLANTATION

### ASSOCIATE OBJECTIVES

1. To inventory the teak plantation to get Teak tree stock and tree growth parameters.
2. 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.
3. 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.
4. To remedy shortcoming identified in a previous audit and assess the forest management activities.

## METHODOLOGIES

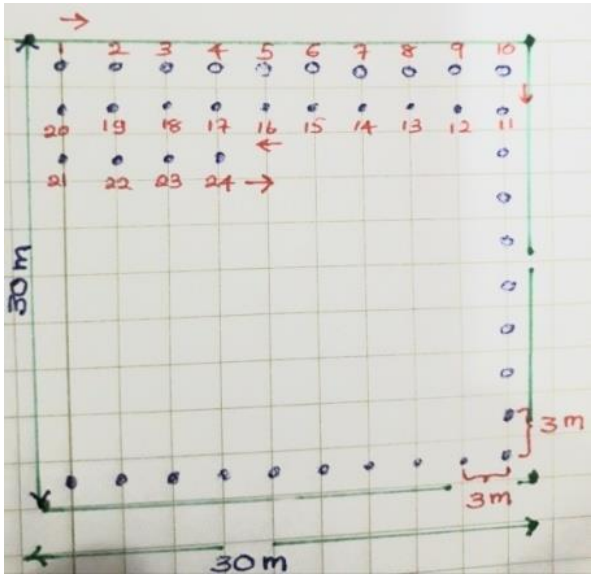
Sound forest management depends on the quantity and quality of information available on the forest. This information is obtained from forest inventories. Forest inventory is the activity of data collection that helps generating the required information base on the forest resource within an area of interest. 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.

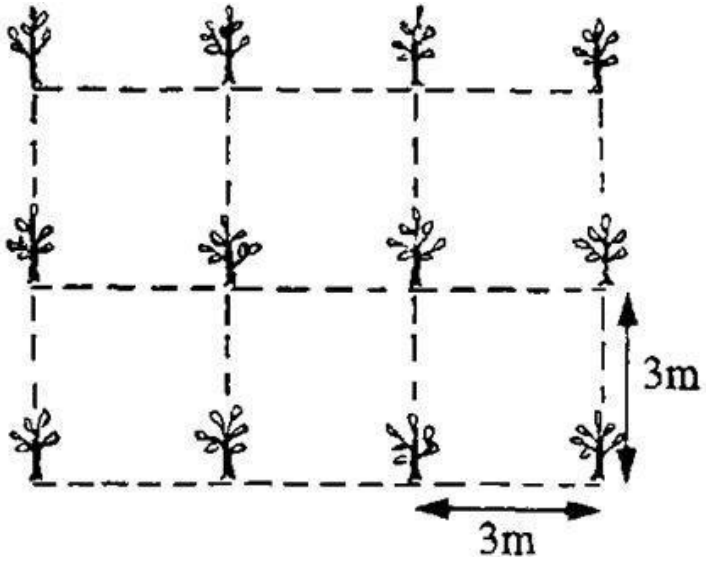
## MATERIALS

- Field assessment datasheets (current and previous)
- Plastic flagging (at least three different colors)
- Sharpie permanent ink pen
- Calculator
- 75' or 100' Spencer tape w/dbh tape
- Clipboard or datum
- Plots mapped
- Digital camera
- Unmarked bearing tree tags for scribing
- Tree paint (spray can): orange or other bright color
- Water
- Field vests
- Mechanical pencils
- Compass
- Small Ruler (metric & English)
- Clinometers
- Stand map
- Small pocket sized notebook
- Numbered tree tags (check for numbers that have not been used)
- Rebar & plastic pipes (for replacement if missing)
- First-aid kit
- Cell phone

## SAMPLING METHODOLGY

Asia Teak Group audit inventory the permanent square shape plots are used and for forest management review works. All the plots of Anamaduwa area is 30m x 30m (900 $m^2$). 10 trees from vertical and horizontal rows were included to plot area. Tree spacing was 3m x 3m.



Diameter of breast height (DBH) measurement was taken using diameter tapes. In most countries breast height level is defined as 1.30 meter above from ground level.

Sunto hypsometer was used to measure the height of the tree. It was estimated the tree according to the trigonometric principles.

When determining site-index, calculating tree volume, evaluating site–quality and predicting future growth of the stand, DBH, Height and the growth is highly useful. Following yield tables were used for the growth information

Proposed thinning regime was applied for the thinning process in the plantation as described follow. According to the priorities stated by the management group thinned trees were decided. First thinning will be doneat age of 11 and second will be at 16$^{th}$. Normally priorities were given for the poor quality trees in the plantation.

## OUTCOMES

As the results of inventory of teak plantation, There were four plots in the Anamaduwa plantation. As shown in table 3, it was shown that each and every plots Mean DBH values, Mean height and the stocking amounts.

***Table 4: Number of trees and tree mean DBH values in plots in Anamaduwa***

| Plot number (P) | Block 01 | | |
|---|---|---|---|
| | No. of trees | Mean DBH (cm) | Mean Height (m) |
| 1 | 73 | 16.87 | 15 |
| 2 | 85 | 14.12 | 11.75 |
| 3 | 81 | 13.24 | 11.9 |
| 4 | 83 | 13.29 | 14.5 |
| Mean | 80.5 | 14.38 | 13.3 |

Lowest stocking was shown by plot no 1 in Anamaduwa teak plantation, while it shown the heighest mean DBH and Height. Plot 2 was shown the opposite parameters for the plot 1 in term of stocking

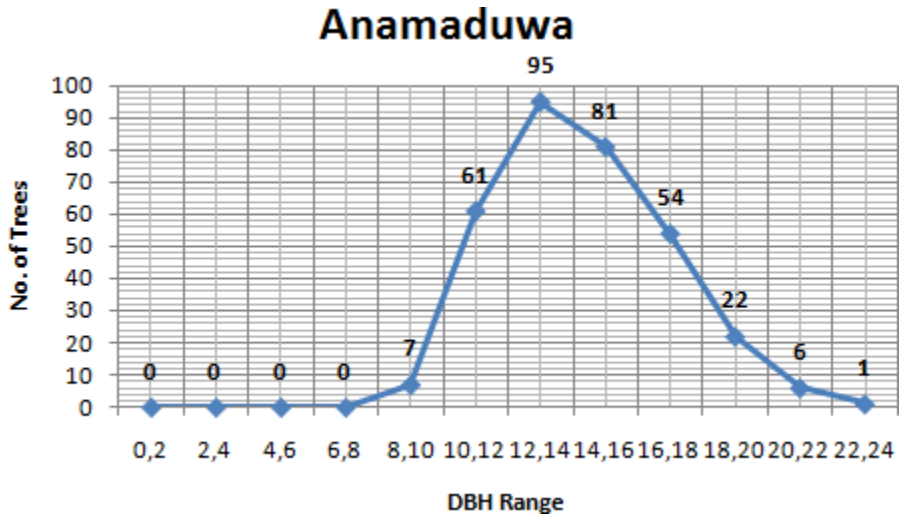



***Fig.2: Number of trees against to average DBH range values in Blocks in Anamaduwa plantation***

Out of 322 of trees, 164 trees are having more than 14 cm dbh. (Mean value is 14.37cm)

It can be assumed that in block no.1. Out of 3683 trees, there are 1875 trees having more than 14 cm DBH category.

***Table 5: Growth parameters and growth rate of Anamaduwa plantation***

| | | 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 |

***Table 6: 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) |

## PLANNING OF THINNING REGIME

Harvesting age (20 years) and number of trees remained for harvesting was predetermined by Asia Teak Company. Additional 10% of trees from reserved tree were maintained up to final harvesting.

This thinning plan was developed based on company management objectives. Anamaduwa plantation is consisting with 4.18 ha and harvesting age of Anamaduwa plantation is 20 years and number of trees to be harvested at the end of rotation is 2492 (2265 +10%).

It is very important to mention here that after first thinning close supervision of tree growth parameter should be monitored. Subsequently intermediate thinning (in between first and second thinning) may be applied.

***Table 7: Thinning regime developed for Anamaduwa plantation***

| 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 | 894 | 14.37 | 13.3 | 0.094/84.4 | | | | | |
| **11/ 2021** | 3047 | 894 | | | | 636 | 155 | First Thinning | | |
| **12/ 2022** | 3047 | 743 | | | | | | | | |
| **13/ 2023** | 3047 | 743 | | | | | | | | |
| **14/ 2024** | 3047 | 743 | | | | | | | | |
| **15/ 2025** | 3047 | 743 | | | | | | | | |
| **16/ 2026** | 2492 | 743 | | | | 555 | 135 | Second Thinning | | |
| **17/ 2027** | 2492 | 607 | | | | | | | | |
| **18/ 2028** | 2492 | 607 | | | | | | | | |
| **19/ 2029** | 2492 | 607 | | | | | | | | |
| **20/ 2030** | 2492 | 607 | | | | | | Final felling | | |

## APPLIED PROCEDURE TO MARK THE TREES FOR THINNING

According to the proposed thinning regime it is estimated that 155 trees can be removed in year 2021 from 11th aged Anamaduwa teak plantation and as the second thinning it can be removed 135 trees in year 2026. Following steps were applied in the thinning regime methodology.

1. 4.1 ha of plantation were divided into 4 blocks.
2. Around 155 trees which was supposed to be thinned out for 1 ha block was distributed with equally spacing.
3. First priority was given for trees which are dead, sick, dying, poor, bad form stem, slow growing in remaining trees.
4. Suppressed, thin whip, under canopy competition, more crowded trees were considered in second priority in thinning process.
5. Few good trees may be marked for thinning in order to give space for the rest of surrounding good trees.
6. Trees which were supposed to be removed were marked in tree map and double checked done whether removing trees were equally distributed within the block.
7. Yellow color paint was used for tree marking.

## SOME OTHER RECOMMENDATIONS FOR THINNING AND MANAGEMANT OF TEAK PLANTATION

In this study, following recommendations were made for application by the Asia Teak Group before implementing the proposed thinning regime (Table 7).

- Selective thinning must be applied after careful study of tree growth parameters and one to one tree inspection. *Marked tree list for thinning (to remove the trees) are annexed herewith (Annex I) as well as the tree map with removing trees were prepared and annexed.*

- Concrete posts at corner of sample plot need to be re-established otherwise unnecessary time is wasted to find the boundary of the plots

- When excess trees build up 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 which can be performed by intermediate thinning.

- Pruning of the adventitious shoots should be carried out only after required training given under close supervision.

## ANNEX

I. Thinning tree list of the plantation

II. Tree Map of the plantation