AsiaTeak Tropical Plantations
Sri Lanka

Tree Audit Report - 2017

By Forest Works Holdings (Private) Limited

Agro Forestry Division

Sri Lanka.

Affirmation of Certifiers

Forest Works Holdings (Private) Limited; is always dedicated in accurate and precise auditing. This assignment is independently carried out by Forest Works Holdings (Private) Limited on the request of AsiaTeak Tropical Plantations Ltd.

The audit covers Teak plantations established by AsiaTeak Tropical Plantations Ltd., in three locations of Sri Lanka. All the plantations were inspected and evaluated under globally accepted methodologies explained in the report.

Herewith, we further substantiate that the inspected plantations are presently in reported conditions.

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1. INTRODUCTION.

The growth and tree stock evaluation report is an annual report presents by Forest Works Holdings for the purpose of certifying the actual situation in AsiaTeak plantations in Sri Lanka.

Forest Works Holdings (pvt) Ltd. is a registered forestry company in Sri Lanka. And it has strong capacity to conduct consultation operations in the field of forestry sector. Many experts on the field of Agro-forestry and the field of Carbon evaluation and carbon conscious are working with Forest Works Holdings (Pvt) Ltd. to enrich the company technical aspects according to the globally accepted methodologies.

2. PRODUCTIVITY AND VOLUME ESTIMATES

The productivity of Teak plantations has been studied across a broad range of countries through permanent sample plots. The earliest yield table for teak was constructed by von Wulfing (1932) for plantations on Java, Indonesia. Laurie and Ram (1939) constructed a yield table for Teak plantations distributed over present-day India, Myanmar and Bangladesh. More recently, yield tables have been developed using data from permanent and temporary sample plots for plantations of teak established outside its natural range, including provisional yield tables for Trinidad and Tobago (Miller, 1969), Côte d'Ivoire (Maitre, 1983), Nigeria (Abayomi, 1984) and Sri Lanka (Phillips, 1995).

Timber corporation in Sri Lanka has developed yield tables for Tectona grandis (Teak) and some other timber trees in Sri Lanka. Yield tables have developed by considering the factors which effects to the growth of the timber trees that grown under the Sri Lankan conditions.

3. ESTABLISHING SAMPLE PLOTS

For forests larger than 3 hectares, the cost involved in measuring every tree becomes prohibitive. By carefully measuring trees within a representative sample of the area it is possible to greatly reduce the time and costs of measuring without losing accuracy. When measuring to assess the volume per hectare, sampling usually involves establishing a number of 'plots' within the forest. Only those trees located within the plots are measured.

3.1 DETERMINING THE NUMBER, SIZE AND SHAPE OF SAMPLE PLOTS

When assessing timber volumes, the ideal number of trees per plot will usually be between 15 and 25. Where there are a number of species or age classes it may be necessary to increase the size of the plot so as to include a representative sample of each. If the stocking

rates are known then the size of the plots can be predetermined. For example, if the stocking rate was expected to be 500 stems per hectare then a plot of 0.04 hectares would be required to include 20 trees.

But by considering the cost factor in commercial forestry plantations, sample plots were established to represent the 10% population of the total tree stock and samples were established by predetermined samples in the grid map of each estate by following the systematic sampling technique.

The best shape for the plots depends on the distribution of the trees and the presence of any gradients, such as slope. In young plantations it is often easier to establish rectangular or quadrangular plots that span a number of planting rows. In native forests or older stands where the trees are more irregularly spaced, large circular plots may be easier to lay out. On steep ground the plot dimensions must take account of slope.

3.2 SAMPLE PLOT ESTABLISHMENT IN ASIATEAK PLANTATIONS

Three plantations are managed by AsiaTeak Plantations in Puttalam and Batticaloa region in Sri Lanka. There are 25 acres land in Puttalam named as Sinnanagavillu estate and 12 acres land in Anamaduwa named as Palugahayaya estate. Other Teak plantation is 120 acres land in Batticaloa named as Kumburuwela estate.

Sample plots have established in all plantations for measuring tree growth rates and volume increments to evaluate the real situation of the plantations for decision making purpose of the management.

4. DIMENSIONS TAKEN FROM SAMPLE PLOTS

4.1 TREE HEIGHT

Tree height is measured by bottom to top of the tree canopy by using a measuring pole that calibrated by standard measuring tapes. Tree height should be recorded to nearest 0.5 m scale.
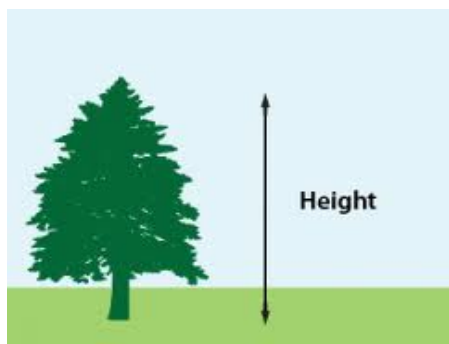

Figure 1: Total Tree Height (m)

4.2 TREE DIAMETER/GIRTH

Tree diameter is the important parameter to evaluate the growth rate of Teak plants. Measuring Diameter at breast height is the standard way to measure the diameter.

Diameter at breast height (DBH) were measured in all sample plots in all plantations. According to the standard way to measure the tree diameter it should be taken at the 1.3 m above from the ground level.
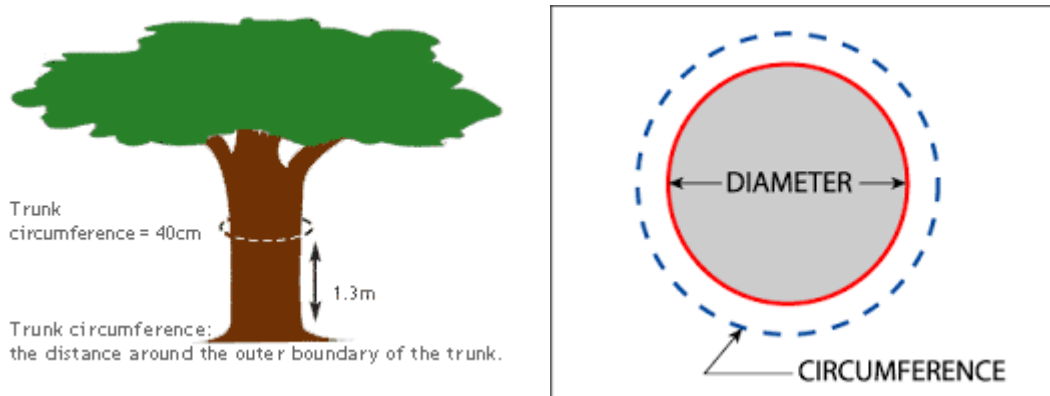
Figure 2: Diameter measurement

5. DATA ANALYSIS
5.1 CURRENT ANNUAL INCREMENT (CAI) AND MEAN ANNUAL INCREMENT (MAI)

CAI and MAI gives us important information about the growth behaviors of plantation. According to this evaluation management plan can be tailor made to achieve the growth targets in each year for

CAI Calculation can be done by reducing the last year average growth by this year average growth. It is the growth performance of current year with the effect of climate conditions, impact of agricultural practices.

MAI is the mean of the growth from first year of the plantation up to now. MAI can be calculated by dividing the current growth by age of trees.

5.2 GROWTH PROJECTIONS OF ASIATEAK PLANTATIONS

Tissue cultured Teak stumps are cultivated by the AsiaTeak plantations for obtaining the best growth rate in the Teak plantations with comparing other general Teak plantations in the world. According to the Thai Orchid Lab company Pvt. Ltd. the proven records are shown that Tissue cultured Teak plants are growing well with short rotation period to achieve the sufficient timber volume in managed Teak plantations.

5.3 TREE STOCK OF ASIATEAK PLANTATIONS IN SRI LANKA IN 2017

Estate	2016			2017			
	No. of Trees Good	No. of Trees Small/Poor	No. of Total Trees	No of good trees	No of Small/poor trees	No of total trees	Difference 2016 VS 2017
Palugahayaya	4471	43	4514	4411	51	4462	-52
Sinnanagavillu	5558	29	5587	5514	38	5552	-35
Kumburuwela Block - 01	2204	176	2380	2039	253	2292	-88
Kumburuwela Block - 02	4213	0	4213	3252	862	4114	-99
Kumburuwela Block - 03	4355	0	4355	3564	605	4169	-186
Kumburuwela Block - 04	3322	0	3322	2693	547	3240	-82
Kumburuwela Block - 05	6760	0	6760	3927	2134	6061	-699
Total Kumburuwela	20854	-	21030	15475	4401	19876	-1154
Grand Total	30883	72	31131	25400	4490	29890	-1241

Table 1: Tree Stock Comparison of 2017 with 2016

❖ Trees that shown some abnormal negative growth when comparing with the average growth level in the age are categorized as small/poor trees. It has represented some poor grown and replanted trees in the Batticaloa estate as small/poor trees.

5.4 GROWTH ANALYSIS OF EACH PLANTATION

5.4.1 PALUGAHAYAYA ESTATE - ANAMADUWA

	Tree Ht (m)					Tree DBH (cm)				
Year	2013	2014	2015	2016	2017	2013	2014	2015	2016	2017
Plot 01	5.5	6.2	6.8	8.7	10.1	6.1	7.5	9.0	10.2	11.7
Plot 02	5.5	6.3	6.7	9.0	9.7	6.1	7.5	9.3	10.2	10.9
Plot 03	5.9	6.9	7.4	11.2	11.7	6.6	8.0	9.8	11.1	12.0
Plot 04	7.0	9.1	8.9	12.3	13.8	7.6	9.7	12.0	13.1	13.7
Average	**6.0**	**7.1**	**7.5**	**10.3**	**11.3**	**6.6**	**8.2**	**10.0**	**11.2**	**12.1**

Table 2: Growth comparison of Palugahayaya estate

Total Average timber volume = 255.84 m^3
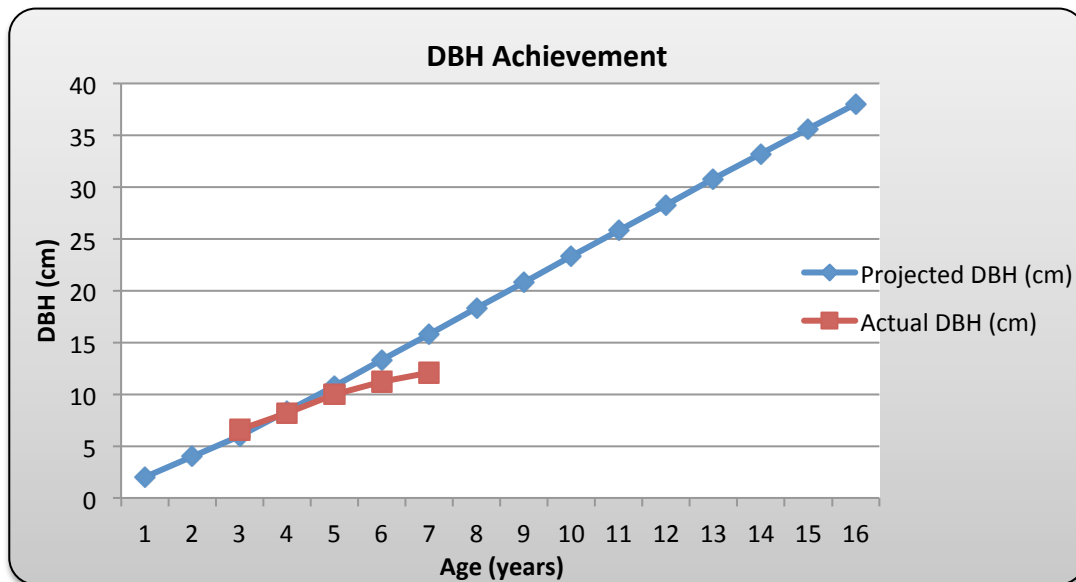
DBH Analysis of Palugahayaya estate-Anamaduwa

Figure 3: DBH achievement of Palugahayaya estate, Anamaduwa DBH Comparison with Projected growth level

Height Analysis of Palugahayaya estate-Anamaduwa
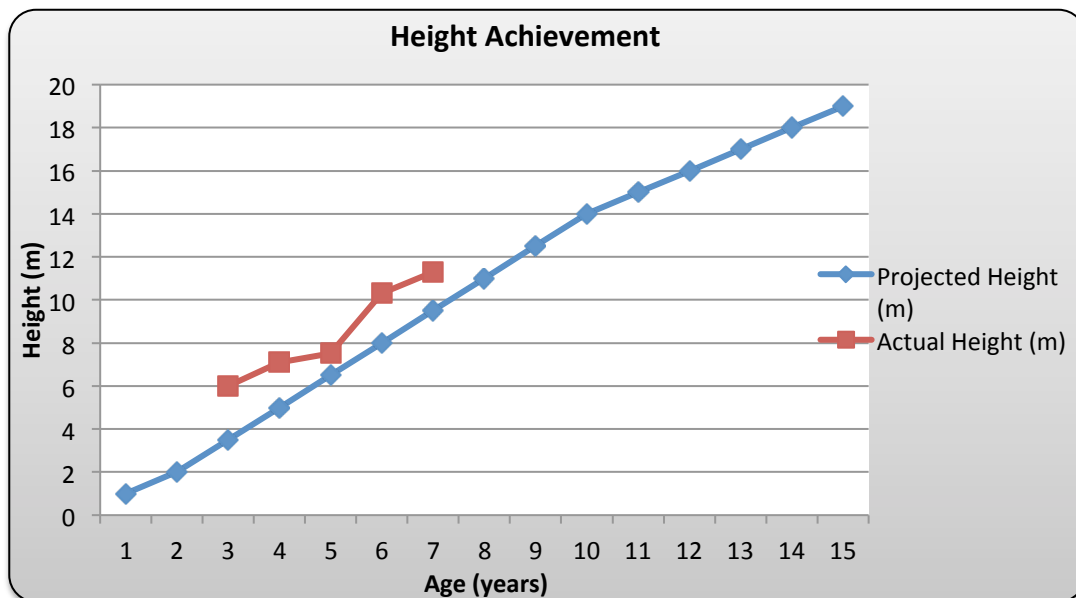
Figure 4: Height achievement of Palugahayaya estate, Anamaduwa (Height Comparison with Projected growth level

MAI & CAI Analysis

Year	Tree Ht (m)					Tree DBH (cm)				
	Year 2013	Year 2014	Year 2015	Year 2016	Year 2017	Year 2013	Year 2014	Year 2015	Year 2016	Year 2017
MAI	2.0	1.8	1.5	1.7	1.6	2.2	2.0	2.0	1.9	1.7
CAI	-	1.1	0.3	2.9	1.0	-	1.6	1.9	1.1	0.9

Table 3: Annual CAI and MAI Changes - Palugahayaya estate

MAI

Figure 5: Mean annual increment of tree height at Palugahayaya estate

Figure 6: Mean annual increment of tree DBH at Palugahayaya estate

CAI

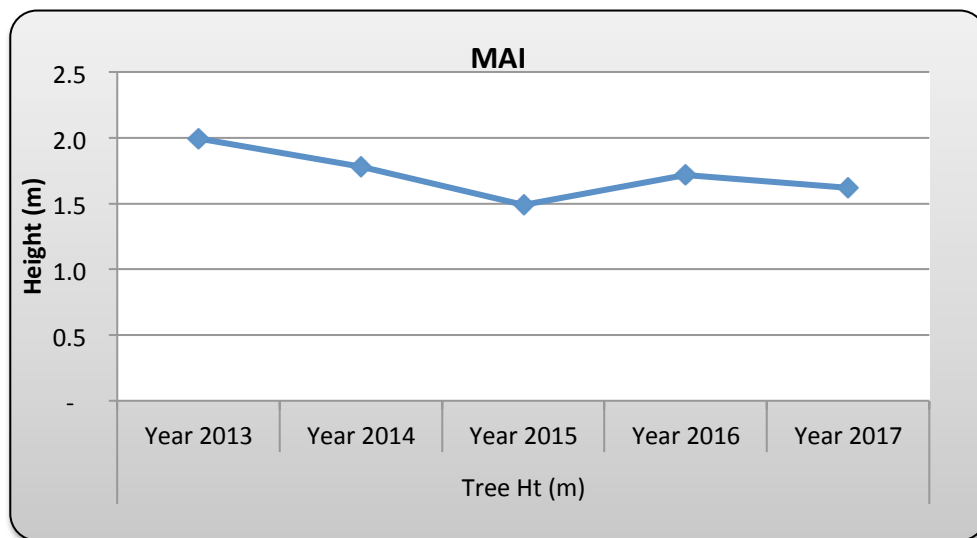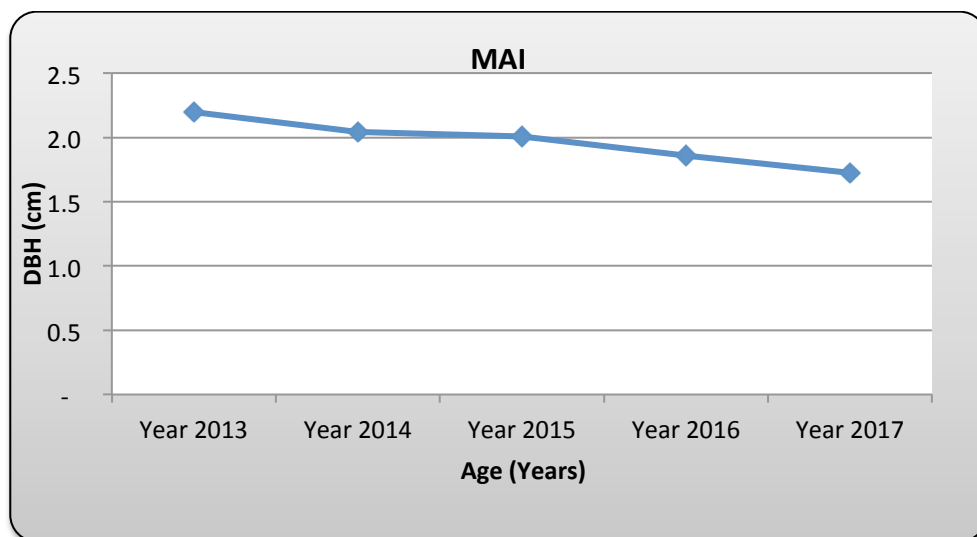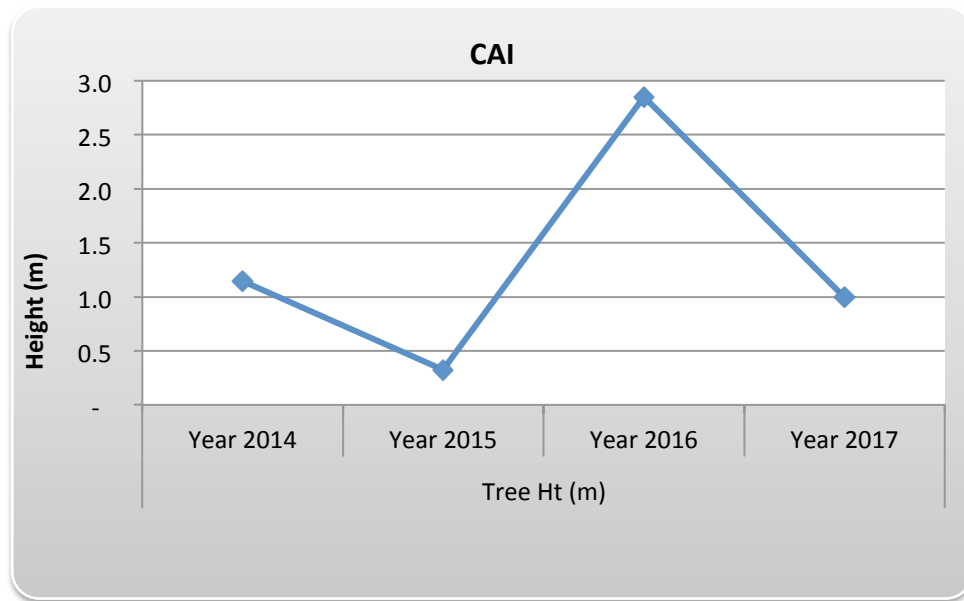*Figure 7: Current annual increment of tree Height in Palugahayaya estate*
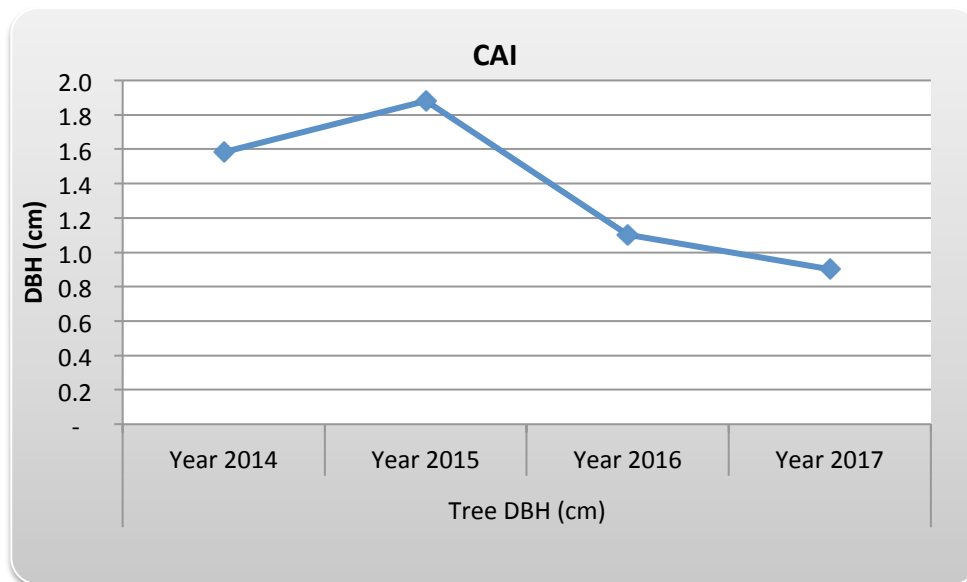

Figure 8: Current annual increment of tree DBH in Palugahayaya estate

5.4.2 GROWTH ANALYSIS OF SINNANAGAVILLU ESTATE-PUTTALAM

Year	Tree Ht (m)				Tree DBH (cm)			
	2014	2015	2016	2017	2014	2015	2016	2017
Plot No. 01	4.7	5.3	7.6	8.5	5.3	7.1	9.6	11.3
Plot No. 02	5.7	6.2	7.4	8.0	4.1	8.9	10.5	12.0
Plot No. 03	5.1	6.1	8.1	9.2	4.4	7.5	10.0	11.9
Plot No. 04	5.4	6.4	8.2	9.3	4.1	8.7	10.9	12.8
Plot No. 05	4.8	6.4	8.7	10.0	3.9	8.4	11.4	13.3
Average	**5.1**	**6.1**	**8.0**	**9.0**	**4.4**	**8.1**	**10.5**	**12.3**

Table 4: Tree growth comparison of Sinnanagavillu estate - Puttalam

<div align="center">

Total Average timber volume = 286.73 m^3

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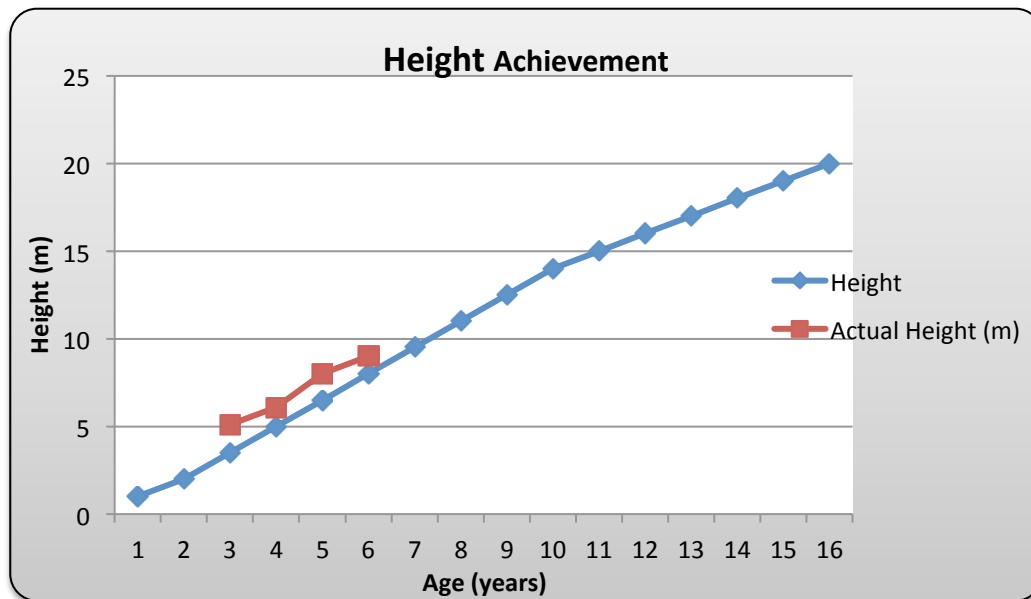## Height Analysis of Sinnanagavillu estate - Puttalam

Figure 9: Height achievement of Palugahayaya estate, Anamaduwa (Height Comparison with Projected growth level)

DBH Analysis of Sinnanagavillu estate - Puttalam
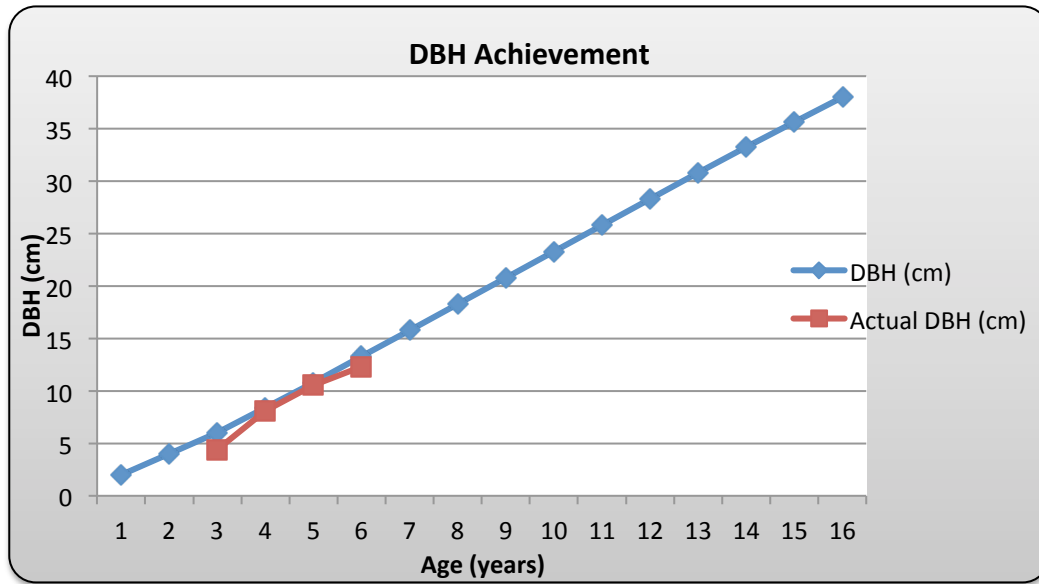
Figure 10: DBH achievement of Palugahayaya estate, Anamaduwa DBH Comparison with Projected growth level

MAI & CAI Analysis

Year	Tree Ht (m)				Tree DBH (cm)			
	year 2014	Year 2015	Year 2016	Year 2017	year 2014	Year 2015	Year 2016	Year 2017
MAI	1.7	1.5	1.6	1.5	1.5	2.0	2.1	2.0
CAI	-	0.9	1.9	1.0	-	3.8	2.4	1.8

Table 5: Annual CAI and MAI Changes - Sinnanagavillu estate

Mean Annual Increment (MAI)

Figure 11: Mean annual increment of tree height in Sinnanagavillu estate

Figure 12: Mean annual increment of tree DBH in Sinnanagavillu estate

Current Annual Increment (CAI)
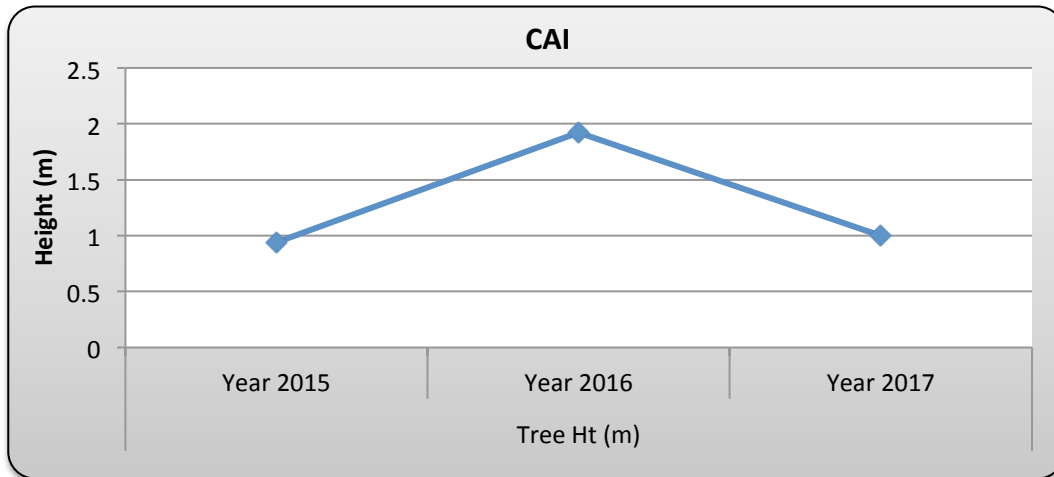
Figure 13: Current annual increment of tree Height in Sinnanagavillu estate.
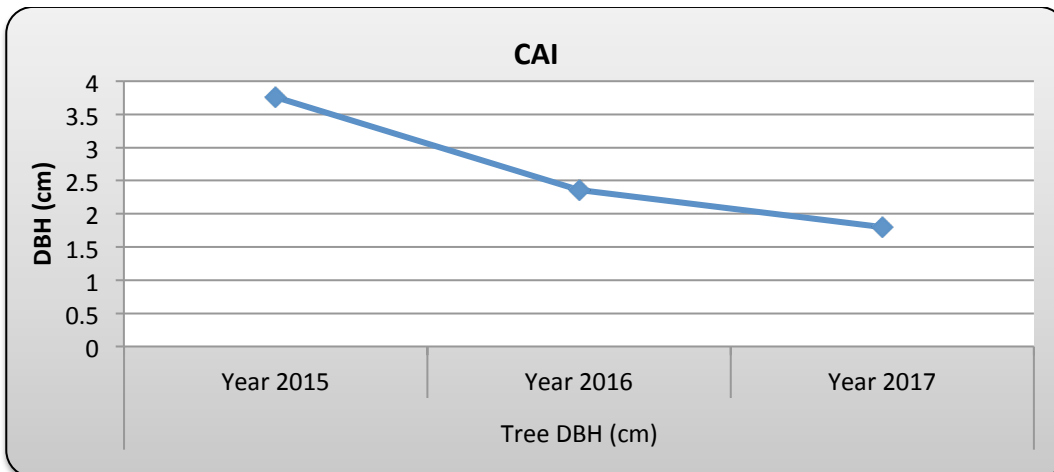
Figure 14: Current annual increment of DBH in Sinnanagavillu estate.
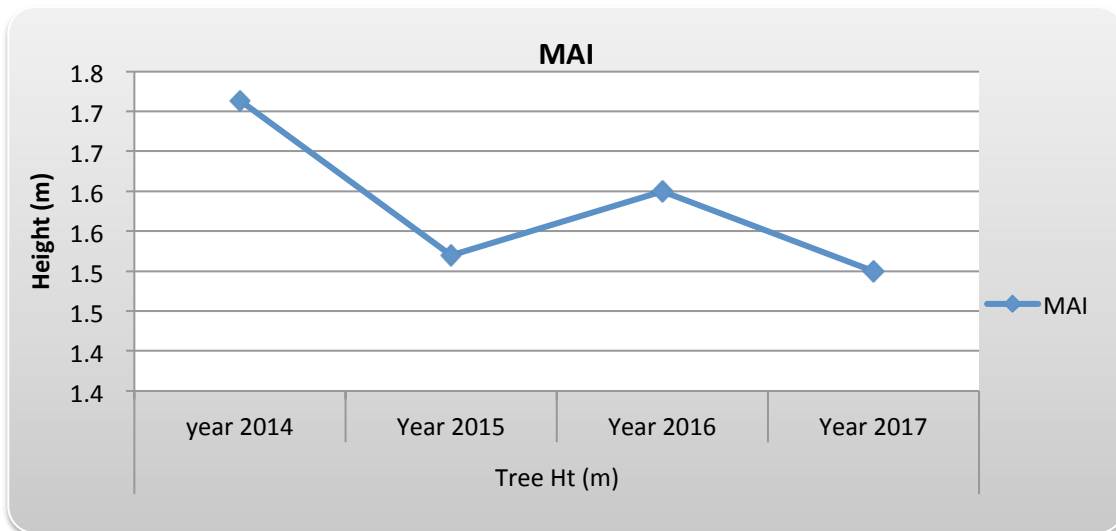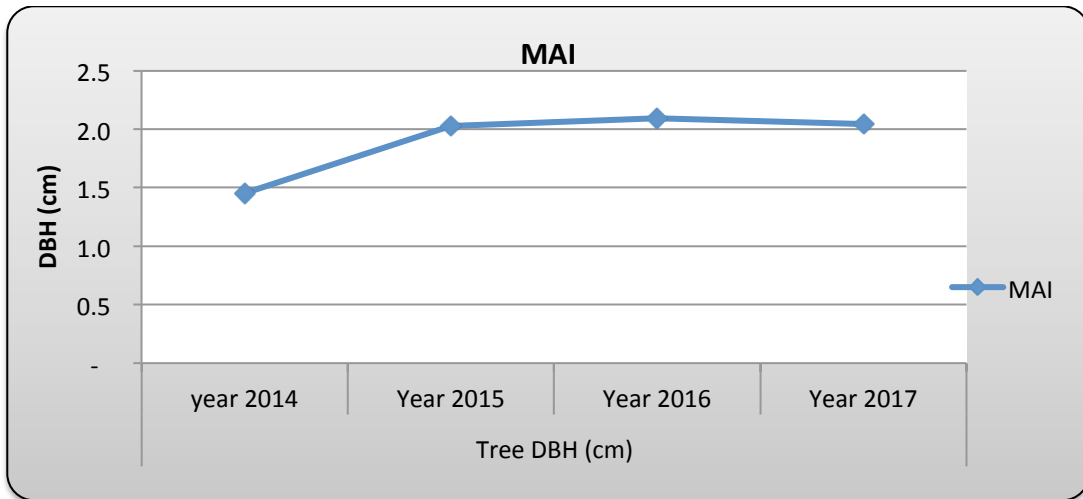
5.4.3 GROWTH ANALYSIS OF KUMBURUWELA ESTATE-BATTICALOA

Block Number 01

Year	Tree Ht (m)			Tree DBH (cm)		
	2015	**2016**	**2017**	**2015**	**2016**	**2017**
Plot No. 01	8.3	9.3	10.1	10.6	13.0	14.7
Plot No. 02	3.3	4.1	4.6	4.2	5.4	5.9
Plot No. 03	3.5	4.5	5.1	4.3	6.0	6.6
Average	**5.0**	**6.0**	**6.6**	**6.3**	**8.1**	**9.0**

Table 6: Tree growth comparison 2016 with 2017 of Kumburuwela Estate-Block number 01

Total Average timber volume = 44.86 m^3

Height Analysis of Block 01, Kumburuwela estate - Batticaloa
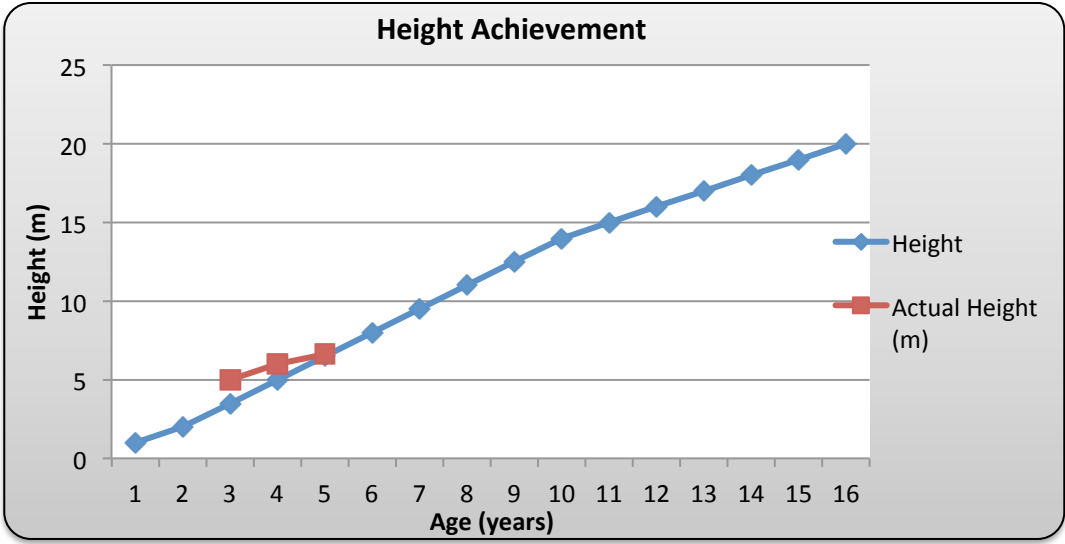
Figure 15: Height achievement of Block 01,Kumburuwela estate, Batticaloa (Height Comparison with Projected growth level)

DBH Analysis of Block 01, Kumburuwela estate - Batticaloa

Figure 16: DBH achievement of Block 01,Kumburuwela estate, Batticaloa (DBH Comparison with Projected growth level)

MAI & CAI Analysis

Year	Tree Ht (m)			Tree DBH (cm)		
	Year 2015	Year 2016	Year 2017	Year 2015	Year 2016	Year 2017
MAI	1.7	1.5	1.3	2.1	2.0	1.8
CAI	-	0.9	0.7	-	1.8	0.9

Table 7: Annual MAI and CAI changes in Block number 01- Kumburuwela Estate.

Mean Annual Increment (MAI) Analysis
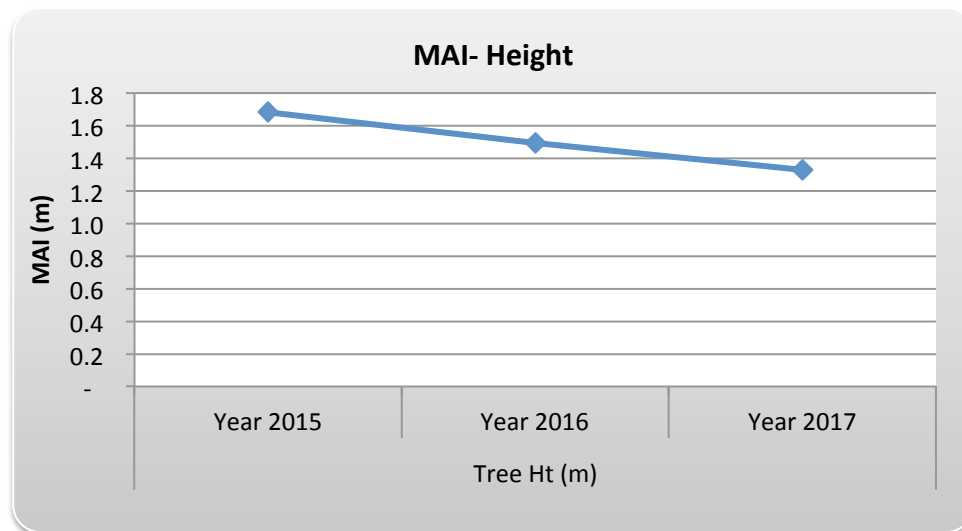
Figure 17: Mean Annual Increment of tree height in Block 01 in Kumburuwela estate
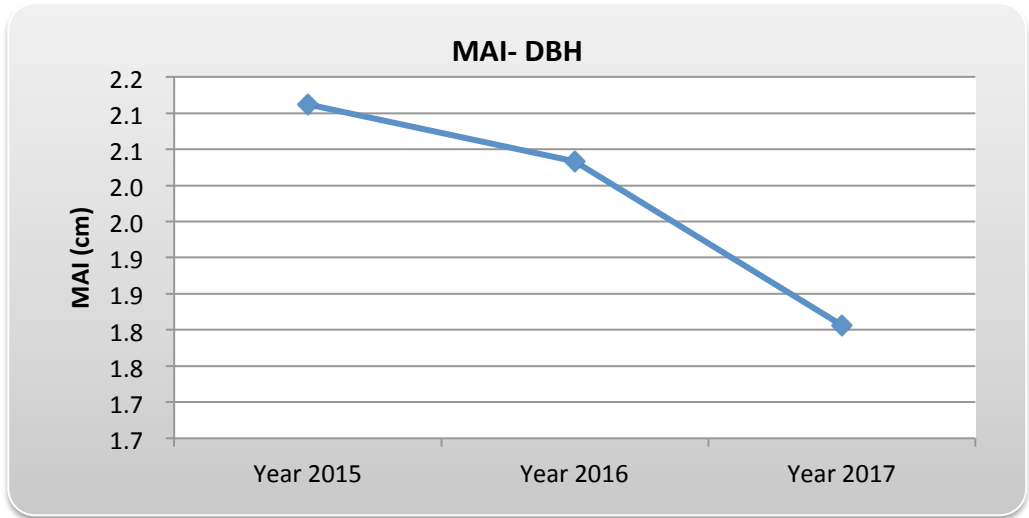
Figure 18: Mean Annual Increment of tree DBH in Block 01 in Kumburuwela estate.

Current Annual Increment (CAI) Analysis
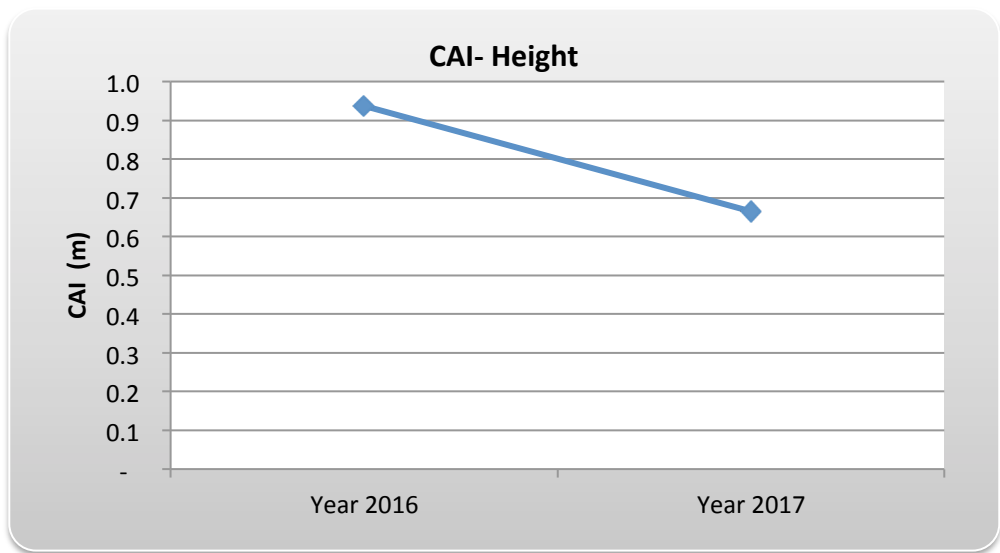
Figure 19: Current Annual Increment of tree height in Block 01 in Kumburuwela estate.
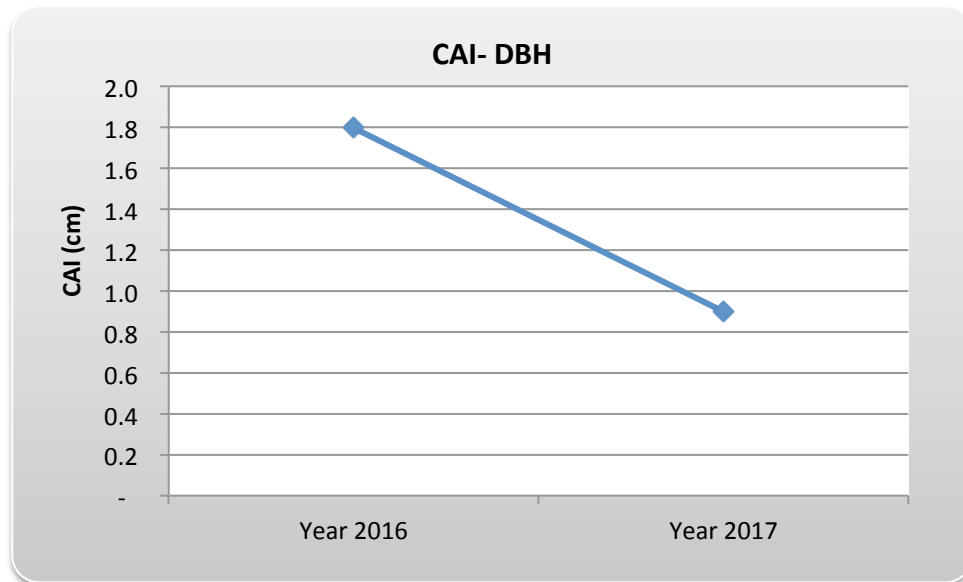
Figure 20: Current Annual Increment of tree DBH in Block 01 in Kumburuwela estate.

Block Number 02

Year	Tree Ht (m)		Tree Ht (m)	Tree DBH (cm)		
	2015	2016	2017	2015	2016	2017
Plot No. 01	2.1	3.9	4.6	2.5	5.3	6.3
Plot No. 02	3.0	5.6	6.4	3.6	6.5	7.8
Plot No. 03	1.8	2.6	3.2	1.9	3.2	4.1
Plot No. 04	3.7	3.0	3.6	3.7	3.0	3.6
Average	**2.3**	**4.0**	**4.7**	**2.7**	**5.0**	**6.1**

Table 8: Tree growth comparison of Kumburuwela Estate-Block number 02

Total Average timber volume = 19.5 m^3

Height Analysis of Block 02, Kumburuwela estate - Batticaloa

Figure 21: Height achievement of Block 02,Kumburuwela estate, Batticaloa (Height Comparison with Projected growth level)

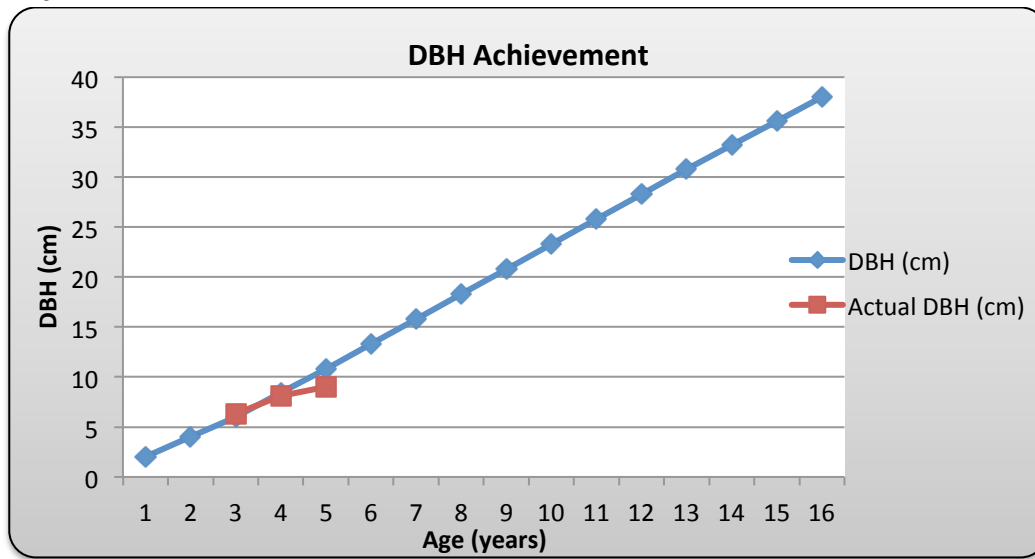## DBH Analysis of Block 02, Kumburuwela estate - Batticaloa

Figure 22: DBH achievement of Block 02,Kumburuwela estate, Batticaloa (DBH Comparison with Projected growth level)

Block Number 03

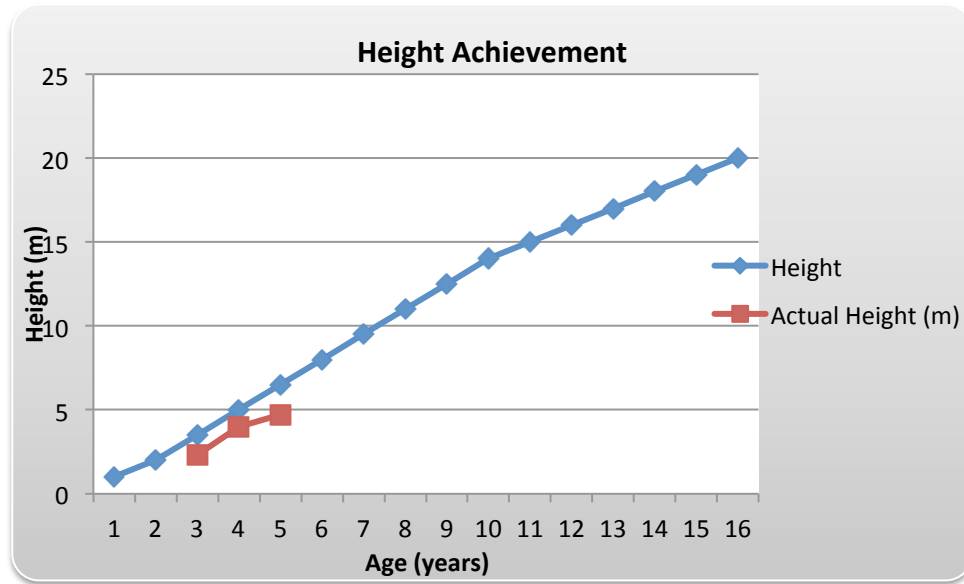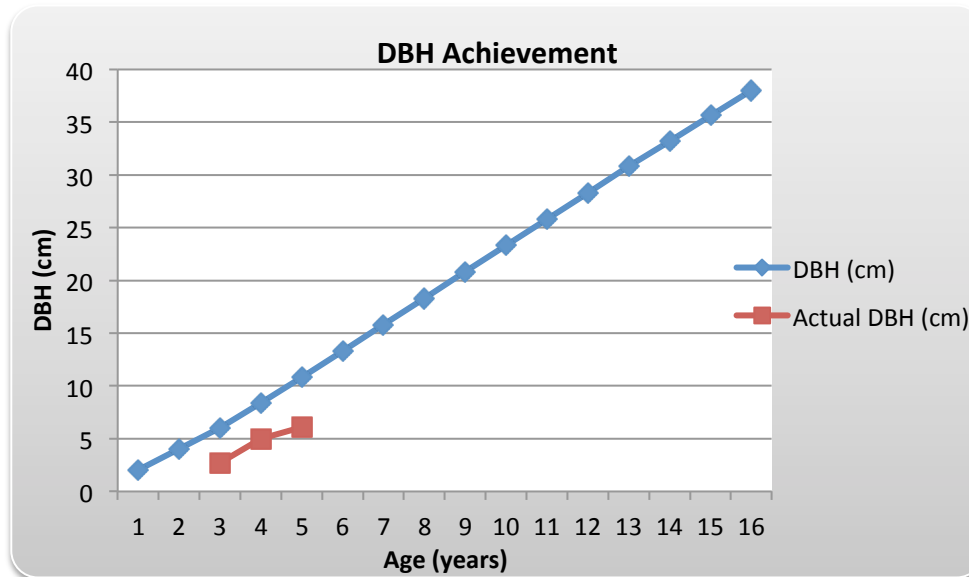| Year		Tree Ht (m)		Tree DBH (cm)
	2016	**2017**	**2016**	**2017**
Plot No. 01	1.795	4.7	2.2	5.6
Plot No. 02	3.745	5.3	4.8	6.7
Plot No. 03	3.93	4.6	5.0	5.9
Plot No. 04	3.89	2.3	3.9	2.3
Average	**3.2**	**4.9**	**4.0**	**6.1**

Table9: Tree growth comparison of Kumburuwela Estate-Block number 03

Block Number 04

Year	Tree Ht (m)		Tree DBH (cm)	
	2016	**2017**	**2016**	**2017**
Plot No. 01	1.6	1.9	1.8	2.5
Plot No. 02	4.3	5.1	5.0	6.4
Plot No. 03	4.6	5.4	5.6	7.1
Average	**3.5**	**4.1**	**4.2**	**5.3**

Table 10: Tree growth comparison of Kumburuwela Estate-Block number 04

Block Number 05

Year	Tree Ht (m)	Tree DBH (cm)
	2017	**2017**
Plot No. 01	2.8	3.0
Plot No. 02	3.0	3.8
Plot No. 03	3.8	4.9
Plot No. 04	2.2	3.0
Plot No. 05	4.6	5.5
Plot No. 06	3.1	3.6
Average	**3.3**	**4.0**

Table 11: Tree growth comparison of Kumburuwela Estate-Block number 05

6. DISCUSSION AND RECOMMENDATIONS

These recommendations are not presents with very thoroughly studying the field and other conditions. Recommendations are presents with basic information gathered in the period of tree auditing.

Palugahayaya estate - Generally plantation condition of Palugahayaya estate in Anamaduwa is in satisfactory level with the actual growth achievements. But the diameter achievement is not up to the projected level due to the trees are more tend to get increase their height than the diameter with the competition among trees for sunlight. And also according to the mean annual increment (MAI) and current annual increment (CAI), the growth rates are shown some draw back in last year.

Hence, it is important to implement some growth rectification programme in accordance with proper silvicultural methodologies. And it is recommended to conduct a light thinning schedule to remove some stunted and suppressed trees in the Palugahayaya plantation.

Sinnanagavillu estate - Trees in Sinnanagavillu estate show satisfactory growth rate of both height and DBH. The actual diameter and height of trees are still in line with projected growth level. Hence, it is important to implement proper silvicultural methodologies to maintained further of this growth conditions to meet the ultimate harvest.

As par the more space than other plantation of among trees in Sinnanagavillu estate, growth of trees is in satisfactory level. Hence it is not recommended to conduct a thinning programme in near future but it is very important to conduct good pruning programme in the estate to achieve a good growth rate.

Kumburuwela estate - Teak trees in block 01 in Kumburuwela estate is still in the satisfactory level of growth and still in line with the projected growth level. But the growth rate in last year is not up to the level and it is illustrated by current annual increment (CAI) and mean annual increment (MAI). As in the CAI and MAI graphs growth achievement is not up to the projected level. Sometimes it could be resulted by the irregular weather pattern which faced last year.

Teak trees in block -02 in Kumburuwela estate are not in the satisfactory level. But it can be rectified by implementing proper silvicultural methodologies and the age of trees is not in the very matured level. Hence it has more adequate time period to well establish in the field and to enhance the condition of the field.

Generally the condition of Kumburuwela estate in average level. Because of that some trees in the field are shown a tremendous growth condition and some are shown very poor growth condition.

7. REFERENCE

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