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TEAK PLANTATIONS IN NILAMBUR

AN ECONOMIC REVIEW

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ABSTRACT

The objectives of the study are to analyse the productivity and profitability of teak plantations in Nilambur North and Nilambur South Divisions. For this yield data for the period 1967 to 1994 covering an area of 12,500 ha was collected. The mean yield in a rotation of 53 years was 151 $m^3 ha^{-1}$ showing a mean annual increment (MAI) of 2.854 m^3 ha^{-1} $year^{-1}$. The average yield obtained correspond to that of site quality IV. Considering the yield of the lowest decile of the area of plantation, the average site quality observed was far below that of the lowest class. Even the yield in the highest decile, the site quality observed was only II/III.

The profitability analysis was done using the current prices and costs of 1995. When no land rent is considered, the net benefit in a rotation of 53 years was Rs.23 lakhs. Net present value (NPV) and benefit cost ratio (BCR) were calculated using different discount rates such as 6, 9, 12 and 18%. At 12% rate of discount the NPV for one hectare of teak plantation with mean yield was Rs.40,000 and the BCK was 3.2. The internal rate of return (IRR) was 31.3%. The maximum land rent possible was calculated as an indication of the surplus available from teak plantations. At 12% rate of discount, for mean yield, the maximum land rent possible was Rs.4500 ha^{-1}.

There is an indication of changes in productivity in teak plantations across time. Careful analysis is required to specify the magnitude of deterioration and the reasons for the same. It is recommended that a more regular assessment of the productivity level in teak plantation be made to monitor the situation and collect data for optimising the rotation age and management inputs.

1. INTRODUCTION

1.1 Background

Teakwood is a valuable multipurpose timber preferred for quality and decorative applications and exported for centuries from India. It is excellent for furniture, doors, decorative veneer, plywood and all sorts of constructions. Teakwood has high rating in most of the timber qualities such as strength, durabdity and workabdity. It has been dcscribcd as one of the most durable timbers of the world (Pearson and Brown 1932). Traditional use of teak poles for electricity transmission and timber for railway sleepers are a time tested testimony of'its suitability for outdoor uses. It is the best timber for ship building and even now sea-going dhows (uru) are built with teakwood in the traditional ship yards of Beypore near Calicut. In the earlier days, Indian, Arab and British merchant and naval ships were built with teak from Malabar. Among Indian timbers, only sandalwood and rosewood command a higher price than that of tcakwood.

Teak *(Tectona grandis* Linn.f) has a natural distribution range of South and South-east Asia. India has the maximum genetic variability of teak with a natural distribution of over 8.9 million ha (Tewari, 1992). For the first time, teak plantations were raised in India in 1842 in Nilambur (Ribbenthrop, 1900). It is cultivated throughout the tropics in varying extent. Teak covers about 14% of the total tropical plantations (Evans, 1982). Extensive teak plantations exist in India outside the zones of its natural distribution. As on plantations in India covered 926,484 ha (Karunakaran, 1995). Nearly 8,000 ha of teak plantations representing about ten percent of all teak plantations in Kerala exist in Nilambur North and South Divisions.

1.2 Review of Literature

There is a profusion of literature on teak and several bibliographies on teak are available but there is very little available on the productivity aspects and even less on the economic aspects. In a literature search spanning ten years from 1985 to 1994 in *Forestry Abstracts, Indian Forester, Forest* Ecology *and Management, Indian Journal of Forestry, Myforest* and in the Monograph on Teak (Tewari, 1992) it was reported that only 1.4% of the publications were related to economics and around 1.4% in the area 'production' (Chacko, 1995).

A recent compilation of annotated references of teak (White, 1993) does not even have a section on economics and reports no publication on economics of teak. Another publication by FAO titled 'Teak in Asia' (FAO, 1993) gives country wise status reports on teak management. Yet except for Bangladesh, which reports that most plantations of teak in that country belonged to site class III with an average yield of 105.9 m^3ha^{-1} at 50 years (Banik, 1993), no other country, including India (Kumaravelu, 1993), gives the productivity or profitability figures for teak plantations.

A monograph on teak (Tewari 1992) gives a comprehensive compilation of the different aspects of teak management, statistics and research. In this volume it is reported that the teak plantations in Nilambur belong to site quality class I and that of Wynad belongs to site quality II based on the standard procedure of site quality determination based on top height of the crop. Although according to the top height measurements Wynad has only site quality 11, according to basal area density of the crop it was equivalent to that of site quality I. This is an indication that site quality determination

on top height alone need not give an accurate picture of the growing stock or potential yields.

The monograph also reproduces two cost-benefit studies in teak done by the Madhya Pradesh Forest Department in 1974 showing that the Internal Rate of Return (IRR) for teak plantations of site quality II/III was 13.9% for a rotation of 60 years in Eastern Maharashtra and that in Bastar District of Madhya Pradesh in site quality I1 the IRR was 12 to 13% for the same rotation. The Benefit-Cost (BC) ratio in each case was 2.95 and 1.8 respectively.

In a pioneering work, Bourne (1922) prepared the first volume and money yield tables for Nilambur teak which show not only the volume of the growing stock at different ages and the yield it also give the value of such yields net of the extraction costs. The money yield tables are based on current (average of 1916-19) rates which can be used for finding the Net Present Value with an appropriate discount rate. Although the procedure for making the money yield tables is simple when the actual volume and yield tables are available, no other money yield tables for teak in Kerala have since been published. Perhaps with teak prices changing on a monthly basis, money yield tables will lose their relevance quickly.

In the teak bibliography by Mathur (1973) 40 references are given in a group 'forest management, business economics of forestry, administration and organisation of forest enterprises'. Most of them refer to the articles in the journal *Tectona,* published from Indonesia in Dutch language. The remaining few are from Burma and general articles on forests or Working Plans from India.

Another bibliography on teak by Krishnamurthy (1975) shows nine references under the subject head, 'Economics and economic products from forest' which again are mostly from Indonesian sources.

However, several studies on the various factors influencing growth and productivity of teak plantations are available. They are mostly centred around site deterioration, fire, pest infestation and management issues. A brief review of relevant studies is given below.

Alexander *et al.* (1987) made a study of the soil properties in different site qualities of teak plantations and observed that variation in site quality of teak plantations is influenced by soil parameters such as gravel, sand, pH and exchange acidity.

In spite of a detailed search no previous studies on analysing the productivity of teak plantation using data collected from a large region covering all age groups could be located. The problem is compounded by the high variability in the productivity and the wide price spread in the price of poles and logs.

A study on the productivity of teak plantations in Konni, Kozhikode, Nilambur and Wyanad Forest Divisions have been concluded by KFRI (1979). The study showed that Nilambur Division had the highest productivity among the four Divisions.

So far, no studies have been carried out with respect to the site quality status and productivity of teak plantations. This study analyses the current

productivity status of teak plantations in relation to the site quality and examines the profitability of teak plantations in Nilambur Divisions.

1.3 Objectives

The Objectives of the study are :

i. to compile the available information on teak plantations in Nilambur North and South Divisions classified according to different site qualities,
ii. to estimate the productivity of teak plantations in Nilambur Divisions,
iii. to analyse the profitability of teak plantations in Nilambur Divisions and
iv. to discuss the yields obtained in relation to the site quality of plantations.

2. METHODOLOGY

In spite of a detailed search no previous studies on analysing the productivity of teak plantation using data collected from a large region covering all age groups could be located. The problem is compounded by the high variability in the productivity and the wide price spread in the price of poles and logs.

There are different operations in the management of a teak plantation such as site clearance, slash burning, land preparation, nursery raising, preparation of stumps, planting, maintenance, weeding, loranthus cutting, periodic thinnings and final felling. The initial planting is done with a spacing of 2 m x 2 m to reduce weed growth and to obtain a straight bole. As the canopy develops, some trees are removed to provide sunlight. There are two types of thinning - mechanical and silvicultural. The first two thinnings at 4^{th} and 8^{th} years are called mechanical thinnings where trees in the alternate diagonals are removed. The subsequent four thinnings are called silvicultural thinnings where stunted and poorly grown trees are removed retaining a healthy crop. Yield obtained during thinning operations is termed as thinning yield.

The trees that remain after the different thinnings are felled at the rotation age in an operation called final felling. This is a clearfelling. The rotation age is the age of the plantation when it is finally felled. The total yield is the sum of all the yields from thinnings and the final felling yield. The mean annual increment (MAI) is an important measure of productivity used in forestry. MAI is obtained by dividing the total yield by the rotation age.

Yield tables for teak plantations have been published by the Forest Research Institute, Dehra Dun (FRI and C, 1970). Yield tables give the expected yields

in thinning and final felling at a particular age. Five year age intervals are used in the yield tables. It also shows the various crop parameters such as crop diameter and top height for different ages.

Site quality refers to the potential of a site to grow a particular crop. It is based on the age and top height of the crop. Usually site quality determination is done only once in a rotation. When Divisional Working Plans are revised at 10 to 15 year intervals, new plantations above 10 year which were not site quality mapped during the previous plan are taken up for site quality mapping. In the case of Nilambur, the latest Working Plan is for the period 1982-83 to 1991-93. Due to reorganisation of forest divisions, currently there are Nilambur North and Nilambur South Divisions. In this study both are considered together and referred to as Nilambur Divisions.

2.1 Data base

The data required for this study were the yields from teak plantations, cost of different operations, price of teakwood and poles, information on site quality of plantations etc. Data were collected from unpublished records such as the files and documents of the Kerala Forest Department.

The Forest Department maintains plantation records at the Range Offices. The plantation journal is an important record to be maintained for each plantation and all details of each plantation such as year of planting, species, area, different operations carried out, costs and revenue are to be recorded. Every work which involves an expenditure or revenue will also have their respective fdes. The Divisional Forest Offices also have fdes on the approval

of estimates of work carried out. Data on yield, cost, etc. used in the study are collected from the above sources.

The maintenance of plantation records at the Range Offices is not given a very high priority which has been observed in a state wide survey by KFRI, (1997). It revealed that plantation journals are available only for 51 percent of teak plantations. Even when these journals are available, the yield data may not be entered in it as these are rarely inspected by senior officers. Due to heavy work load in the Forest Range Offices, perusal of all the files for collecting yield statistics was not easy. The strategy, therefore, was to collect the entire yield data that was available. In Nilambur, yield data was obtained for 251 plantations worked during the period 1967-81 and 117 plantations worked during 1982-94. Together they covered 12,536 ha. This area is much more than the existing teak plantations in Nilambur. Many older plantations included here have been felled and the area replanted. The data on yield were collected and compiled (see Appendix-1 for data). After sorting, those operations that were beyond a reasonable age limit were eliminated. Extremely delayed thinning operations distort the mean yields and do not permit to keep exclusive age limits for each thinning operation. (see Appendix : 2 for division wise distribution and Appendix : 1 for yield data.)

Teak timber from plantations is transported to different timber depots maintained by the Forest Department. At the depot, logs are classified and arranged on the basis of length, girth and quality. The criteria of classification of logs are given in Appendix 3. Logs of the same size and quality classes are grouped into lots of not more than 5 m3.These lots are sold in monthly open competitive auction. Each depot has separate fdes for each monthly auction. Price data for different girth and quality classes for the year 1995 were

collected from Chaliyam, Nedumkavam and Aruvakode Government depots. Poles from young plantations are usually sold at the plantation site by the Range Officer by auction. Prices of poles were collected from the files maintained at the Range Offices.

Ten to fifteen year Working Plans are prepared for each Forest Division. Working Plans are documents giving management prescriptions, thinning schedule, rotation age etc. Site quality information on plantations is compiled from these Working Plans. Publications from the forest headquarters such as Annual Administration Reports and Forest Statistics are the other sources of information and data.

2.2 Productivity analysis

For the productivity analvsis, the parameters used are mean yield, MAI and expected vield in different site qualities. Teak plantations in Kerala are managed on a rotation of 60 or more years except in Nilambur Forest Divisions which follows a 50 year rotation. Productivity analysis has been done for Nilambur Divisions and the results are presented in section 3. Due to the long tradition of teak growing in Nilambur, detailed analysis for Nilambur North and Nilambur South Forest Divisions were carried out.

The procedure for the calculation of mean yield is as follows: The yield data collected was grouped operation wise. Within each operation, weighted average yield per ha was worked out considering the area of each plantation as the weight. These weighted average yields were added together to arrive at the total yields per hectare. Due to great variability in yield within an

operation, the minimum, maximum and coefficient of variation are also shown.

Teak plantations in Nilambur were managed on a rotation of 60 years prior to early 1980s. Later it was reduced to 50 years as per the Working Plan of Ranganathan(l981). The yield data collected were therefore classified for two periods 1967-81 and 1982-94. Mean yields were computed as mentioned earlier for each of the two periods. Both periods were combined and the mean yield of the entire period was computed.

Apart from showing the minimum and maximum yield obtained in different periods, low and high yields were also calculated.The low yield represent the mean yield correspondmg to the lowest decile of area under plantation when the yields are arranged in the ascending order. Likewise, the high yield represents the mean yield for the highest decile.

For evaluating the performance of teak plantations, the actual mean yields were compared with the expected yields for different site quality classes available in the All India Yield Tables for teak. Based on the yields realised, the average site quality attained was also assessed.

The mean yields obtained per hectare for each set of operation were calculated. For calculating the mean yields, weighted average was taken using the area of plantation as the weight. For examining the variability, the coefficient of variation was worked out for each operation.

Conventionally, the site quality. of a plantation is a good indicator of the productivity or yield levels that can be expected. An attempt has been made

to compare the actual timber yield/production in Nilambur with the site quality which is the potential productivity.

The question whether there is any perceptible change in the productivity of teak plantations over time has also been looked into by examining the yields obtained in different operations based on the period in which the plantations were raised.

2.3 Profitability analysis

Profitability analysis requires data on the stream of costs and returns from the time of raising nursery to the final felling of the plantation. The data on costs include nursery raising, slash burning of plantation site and land preparation, aligning and staking to mark the position for planting, planting of stumps in crowbar holes, maintenance, cultural operations, weeding, tending, climber cutting, epiphyte (loranthus) cutting, periodic thinning operations and final felling. The returns include yields in the form of timber, poles and firewood billets obtained in different thinning operations such as first and second mechanical thinning (lM, 2M), first to fourth silvicultural thinnings (lS, 2S, 3S and 4S) and final felling.

The average cost for each operation was obtained from the working costs actually incurred in different ranges in 1995. This method was adopted because it is the best way to arrive at the real prices necessary for cost benefit analysis.

If past prices are used, it is necessary to use some price indices to obtain the real prices. If All India wholesale price indices or that of wood and wood

products are used, it may have a different trend than that of the trend in the local costs and prices. In the indices of wood and wood products major components such as pulpwood, plywood, furniture etc. are included and it is not specific to log prices in Kerala.

The average cost per ha for different operations (from nursery raising to final felling) was compiled from the 1995 cost data from all the forest ranges in Nilambur. There is an approved schedule of rate for the different operations in plantation management. A provision for slightly higher rates is also made to take care of the difficulties encountered in some areas due to inaccessible type of terrain etc. Accordingly, Ranges have been classified as ordinary, difficult and very difficult based on accessibility. The cost figures used in this study are based on the average expenditure per ha actually incurred in different operations during 1995. These figures have been collected from range records. For thinning and final felling the expenditure per ha is related to the actual yield obtained. Therefore the costs per m^3 of yield obtained was found out and this was used to calculate the per ha costs.

The method adopted for valuing the stream of returns is as follows. In each thinning and final felling operation, different classes of poles and logs are obtained. For example the yield in the 3^{rd} silvicultural thinning includes poles of different size classes and logs of different girth and quality classes. The prices of different categories of poles and timber vary greatly. For the valuation of yield from different operations, the break-up of yield into different size and quality classes are required. The break up of yield obtained from the plantation journals, files and other records were converted into per ha terms for each operation. The mean distribution was then worked out for each operation.

The percentage distribution was used for distributing the mean yields into different items of poles and timber in different operations. The weighed average prices of each item needed for estimating the financial returns were worked out taking quantity sold of that item as weight using the auction prices of timber sold in government depots in 1995. The average prices of poles were obtained from data collected from the range offices in Nilambur. The value of each item of yield in an operation was worked out by multiplying the average quantity per ha of the item with its average price. The total financial returns for each operation were obtained by aggregating the values of all items for each operation. The financial returns were estimated for the low and high yields also.

The maximum and minimum yields represent extreme values. Thus they cannot be used for economic analysis and therefore, the mean yields corresponding to the highest and lowest deciles based on the total area of plantations for each operation were calculated. These have been represented as high and low yields respectively.

The profitability analysis was carried out following the procedure given in Gregersen and Contreras (1992). From the stream of costs and returns, cash flow tables were prepared for mean, low and high yields. Net present value (NPV) was computed using the formula

$$NPV = \sum_{t=0}^{n} \frac{B_t - C_t}{(1+i)^t}$$

where NPV, B_t, C_t, n, and i denotes Net present value (Rs.), Benefit (Rs.) in the year t, Cost (Rs.) in the year t, Rotation age in years and Discount rate respectively.

Internal Rate of Return (IRR) is that discount rate for which NPV=0

i.e. IRR = i such that $\sum_{t=0}^{n} \frac{B_t - C_t}{(1+i)^t} = 0$

For a project to be profitable, the NPV should be greater than zero. The criterion for finding a project to be profitable on the basis of IRR is that IRR should exceed the consumption rate of interest (World Bank, 1976). However, a discount rate is usually selected arbitrarily taking into account time preference and inflation. Price (1989) suggests that the real discount rate can be calculated on the basis of money interest rate and inflation rate. To account for fluctuations in both the rates, in this study, four discount rates from 6 to 18% were considered for the financial analysis so that the sensitivity of the results to different rates can be observed.

As government teak plantations are raised in reserved forest land, no land rent is payable. As the forest policy of Government of India do not permit the conversion of forest land to other uses, other land use options do not exist. There is certainly an opportunity cost of converting natural forest into teak plantations as bio-diversity, wilderness and aesthetic values are reduced when natural mixed forest are converted to monoculture teak plantations. Conversion of natural forests to teak plantations are not permitted under the current forest policy. Only the existing plantations continue to be managed as plantations. Therefore in this study the opportunity cost is not considered as no conversions take place now.

Forest land leased out to public sector corporations such as Plantation Corporation of Kerala, State Farming Corporation of Kerala etc. are charged

a lease rent of Rs.1300 ha^{-1}. This rate has been fixed a few years back and it may shortly be revised. Therefore, in the profitability analysis three options of land rent are considered, 1) without land rent, 2) with a land rent of Rs.l300ha^{-1} and 3) with a land rent of Rs.2500 ha^{-1} to examine the effect on profitability. Besides these, the maximum surplus that can be generated was calculated and shown as the maximum land rent possible

Apart from NPV and IRK, benefit cost ratio (B/C ratio) was also computed. B/C ratio is the ratio of the discounted total benefits to discounted total costs. The B/C ratio should exceed 1 for considering a project as profitable. The NPV and B/C ratio were calculated for different discount rates and profitability analysis was done. Using discount rates of 6, 9, 12 and 18% , the NPV and B/C ratio was calculated to find the profitability of teak plantations.

3. PRODUCTIVITY OF TEAK PLANTATIONS

Yield from teak plantations is obtained from a series of thinning operations and final felling. The different types of work in teak plantations are first mechanical thinning (IM), second mechanical thinning (2M), four silvicultural thinnings (1S to 4S) and final felling (FF). Total yield is the sum of yields from periodic thinnings and final felling. Productivity is measured in terms of total yield or mean annual increment (MAI). When total yield is divided by the age of final harvest, the rotation age, MAI is obtained.

In this section, productivity of teak plantations in Nilambur North and Nilambur South Forest Divisions, based on actual yields is analysed.

3.1 Productivity in Nilambur Divisions

3.1.1 Yields in different periods

Average yield obtained in different operations during the periods 1967 to 1981, 1982 to 1994 and for the entire period (1967 to 1994) was computed and presented in Tables 4.1, 4.2 and 4.3 respectively. The mean age of thinnings and final felling are different for each period. The age range within which each set of operations was carried out is also shown. Total area refers to the total area of plantations for which the yield data were obtained. When yield data from more than one operation are available, the area is added again so that the total area is more than the existing plantation area. It may be noted that data from different operations in the same plantations are accounted here separately so that 372 plantations only indicate that the data from 372 thinning and final felling operations have been included in the analysis.

The total number of plantations (operations) given in Table 3.3 is not the sum of that in Table 3.1 and 3.2, since the age limits for different operations in all the three sets are different. Four plantations excluded earlier were included in the combined period as the age limits were wider. Appendix 4 gives the age limits considered for different types of work.

The mean yield for each operation in the table is the weighted mean using area of the plantation as the weight. To show the degree of variability in yield between plantations, the minimum and maximum yields obtained are shown. The coefficient of variation is also presented in the tables.

Table : 3.1
Average yield from teak plantations in Nilambur Divisions worked during the period 1967 to 1981

Type of work	Mean age	No of Plantations	Total Area (ha).	Yield (m^3/ha)			
				Mean	CV(%)*	Min	Max
1M	5	10	377.217	5.729	56.0	1.038	11.648
2M	8	24	1071.752	6.158	21.5	3.602	10.737
1S	12	30	1379.413	7.070	26.7	0.215	10.996
2S	18	34	1568.731	4.979	76.3	0.174	13.857
3S	29	53	1565.240	17.418	39.2	1.983	24.732
4S	41	78	1605.280	16.791	37.5	4.674	45.468
FF	56	22	774.388	107.250	40.2	57.911	225.735
Total		251	8342.021	165.396		69.597	343.173
MAI at 56 Years (m3/ha/yr)				2.954		1.243	6.128

CV - Coefficient of variation

Source : Computed from data collected from files of the Forest Department

Table : 3.2
Average yield from teak plantations in Nilambur Divisions worked during the period 1982 to 1994

Type of work	Mean age	No of Plantations	Total area (ha).	Yield (m^3/ha)			
				Mean	cv(%)	Min	Max
1M	6	16	511.348	3.838	74.4	1.038	10.202
2M	9	19	834.452	5.784	60.4	1.423	14.801
1S	13	26	1008.710	2.915	99.5	0.380	12.067
2S	19	14	513.777	4.728	86.1	0.110	15.998
3S	27	12	535.970	10.571	87.0	2.966	35.749
4S	38	8	224.023	7.187	54.2	2.292	12.626
FF	51	22	406.441	70.251	64.1	28.623	231.054
Total		117	4034.721	105.272		36.832	332.497
MAI at 51 Years (m^3/ha/yr)				2.064		0.722	6.520

Source : Computed from data collected from files of the Forest Department

Table : 3.3
Average yield from teak plantations in Nilambur Divisions worked during the period 1967 to 1994

Type of work	Mean age	*No of Plantations	Total area (ha).	Yield (m^3/ha)			
				Mean	cv(%)	Min	Max
1M	6	26	888.565	4.641	62.0	1.038	11.648
2M	8	43	1906.204	5.994	42.1	1.423	14.801
1S	13	57	2411.523	5.291	56.5	0.215	12.067
2S	19	48	2082.508	4.917	79.3	0.110	15.998
3S	28	65	2101.210	15.672	50.6	1.983	35.749
4S	41	86	1829.303	15.615	45.1	2.292	45.468
FF	53	47	1316.844	99.128	47.3	28.623	231.054
Total		372	12536.157	151.257		35.684	366.785
MAI at 53 Years (m^3/ha/yr)				2.854		0.673	6.920

* As the age limits are wider, 4 more plantations worked during the period 1967-81 are included here.

Source : Computed from data collected from files of the Forest Department

During the period 1967 to 1981, the mean total yield from 251 operations covering 8342 ha was 165m^3 ha^{-1} and MAI at 56 years was 2.954m^3 ha^{-1} $year^{-1}$. During the period 1982-94 the mean total yield from 117 operations covering 4035 ha was 105m^3 and MAI at 51 years was 2.064 m^3 ha^{-1} $year^{-1}$. For comparison of the productivity between the two periods it is not enough to compare the total yield as the rotation ages are different. Therefore the MAI for the two periods is used for the comparison. The productivity, as observed from the MAI, is higher in the period 1967-81 than in the subsequent period 1982-94. It may be noted that the variability in yield is more pronounced during the period 1982-94 than during 1967-1981.

During the period 1967-1994, pooling the data from 372 plantations covering 12536 ha, the mean age of final felling became 53 years. The MAI at 53 years was found to be 2.854m^3 ha^{-1} yr^{-1} which is the mean productivity of teak plantations in Nilambur Divisions. This estimated mean yield is used in the profitability analysis.

In Tables 3.1 to 3.3, the maximum and minimum yields in each type of work are shown. The minimum and maximum are extreme values which are not used for further analysis. For this, the yields representing the lowest and highest ten percent of area were estimated when yields were arranged in the ascending order. These are the mean yields in the lowest decile and the highest decile of the entire data. The yields in the lowest decile and highest decile are hereafter called 'low yield' and 'high yield' and they are used later in the profitability analysis. Table 3.4 shows the estimates of mean yields representing the entire data and those in the lowest and highest deciles. The estimated MAI in the lowest decile is 0.973 $m^3ha^{-1}yr^{-1}$ and that in the highest

decile is 5.641 $m^3ha^{-1}yr^{-1}$. The MAI in the highest decile can be considered as the potential productivity in good sites in Nilambur Divisions.

Table : 3.4
Mean, low and high yields from teak plantations in Nilambur Divisions during the period 1967 to 1994

Type of Work	Mean	Low*	High*
1M	4.641	1.172	10.434
2M	5.994	2.365	11.459
1S	5.291	0.425	8.643
2S	4.917	0.159	10.989
3S	15.672	3.444	26.963
4S	15.615	4.461	26.029
FF	99.128	39.543	204.475
Total	151.258	51.569	298.992
MAI at 53 Years	2.854	0.973	5.641

*The low and high yields represent the mean yields in the lowest and highest deciles respectively.
Source : Computed from data collected from files of the Forest Department

3.1.2. Expected yields in different site quality classes

Yield of a plantation has a meaning only in relation to the potential of the species in the locality. Fortunately, yield tables for teak have been published by Forest Research Institute and College (1970) incorporating a large number of sample plots from Nilambur Divisions, the oldest teak plantations in India.

Site quality is a measure of productive capacity of a site for a particular species. For teak plantations in India, different site quality classes have been

identified. Site quality class I is the highest class and IV is the lowest. The site quality is determined based on the top height of the crop.

All India yield tables of teak show seven site quality classes including fractional quality classes and the estimated yield from thinning and final felling at five-year intervals. In the present study the mean ages obtained for thinning are 6, 8, 13, 19,28 and 41 years. As the expected yields for the above years are not available in the All India Yield Tables, the corresponding expected yields have been interpolated and presented in Appendix 5. Similarly the expected yield in final felling are also available in the yield tables only at five year intervals. The expected final felling yields for the years in between have been interpolated and given in Appendix 6. From these two Appendices the yields expected in thinning and final felling for the mean age of different operations in different site quality classes are shown in Table 3.5. In the first mechanical thinning (lM), the expected yield in site quality I at the age of 6 years is 22.32 m^3ha^{-1}, whereas in site quality IV it is only 1.47 m^3ha^{-1}. Similarly in site quality I, the expected yield at final felling at the age of 53 years is 271.63 $m^3ha^{-1}$and that in site quality IV is 68.71 m^3ha^{-1}.

The expected total yield for different site quality classes is also available only in five year intervals. As the mean rotation age for Nilambur Divisions is 53 years, the expected total yields and MAI for selected years are interpolated and shown in Table 3.6. For site quality I plantation, the expected total yield is 520 m^3 and MAI at 53 years 9.84 m^3 ha^{-1} $year^{-1}$. For site quality IV plantation, the expected total yield at the same age is 112 m^3 and MAI is 2.1 $3m^3$ ha^{-1} $year^{-1}$.

Table : 3.5

Yield expected in thinnings and final felling in different site quality classes

Type of work	age	Yield in different site quality classes (m^3ha^{-1})						
		I	1/11	II	II/III	I11	III/IV	IV
1M	6	22.32	21.13	19.24	16.72	13.85	2.17	1.47
2M	8	24.78	23.51	21.34	17.98	14.27	6.51	4.41
1S	13	29.32	27.15	24.28	19.66	14.90	10.64	7.14
2S	19	36.04	30.79	25.12	19.10	14.20	9.94	6.44
3S	28	31.56	26.80	21.20	15.25	12.46	8.68	5.18
4S	41	18.96	16.93	14.62	12.04	9.31	6.51	3.43
FF	53	271.63	225.73	182.91	144.77	113.70	90.26	68.71

Source : Interpolated from FRI and C (1970) and converted to metric units.

Table : 3.6
Total yield and MAI for specific ages for different site quality classes

Age	Item	Yield in different site quality classes ($m^3 ha^{-1}$)						
		I	I/II	II	II/III	III	III/IV	IV
20	Total yield	224.961	212.366	184.727	151.140	119.653	78.019	55.628
	MAI	11.27	10.64	9.24	7.56	6.02	3.92	2.80
50	Total yield	499.952	427.881	354.410	280.239	220.413	156.738	107.757
	MA1	10.01	8.54	7.07	5.60	4.41	3.15	2.17
51	Total yield	506.669	434.038	359.728	284.647	223.561	158.697	109.297
	MAI	9.95	8.49	7.04	5.58	4.38	3.12	2.16
53	Total yield	520.104	446.353	370.363	293.464	229.859	162.616	112.376
	MAI	9.84	8.41	6.98	5.56	4.32	3.06	2.13
55	Total yield	533.539	458.668	380.999	302.280	236.157	166.534	115.454
	MAI	9.73	8.33	6.93	5.53	4.27	3.01	2.10
56	Total yield	539.277	464.196	386.177	306.899	239.655	168.983	116.924
	MAI	9.66	8.28	6.90	5.51	4.25	3.01	2.09
58	Total yield	'550.752	475.252	396.533	316.135	246.652	173.881	119.863
	MAI	9.52	8.20	6.84	5.49	4.23	3.01	2.06
60	Total yield	562.227	46.307	406.889	325.371	253.650	178.779	122.801
	MAI	9.38	8.12	6.79	5.46	4.20	3.01	2.03
65	Total yield	588.467	510.798	429.280	347.412	273.242	191.024	131.898
	MAI	9.03	7.84	6.58	5.32	4.20	2.94	2.03

Source : Interpolated from FRI and C (1970) and converted to metric units.

3.2 Comparison of site quality and actual yields

Information on site quality is available only for plantations planted prior to 1967. Table 3.7 shows the distribution of plantations for which site quality information is obtained and at least one yield figure is available. Out of 292 plantations extending to 9603 ha., site quality information of 247 plantations

covering 7680 ha is available from Working Plans. Along with the field work for this project, the site quality for 45 teak plantations has been determined by the conventional method. Appendix 7 gives the list of those plantations and their site qualities.

Table 3.8 gives the distribution of plantation for which both site quality information and yield of any type of work are available. It shows the number of plantations and area operation-wise. All the plantations may not at present be standing, particularly those which were finally felled.

Site quality information of a plantation has many uses. It can be used for site selection, yield regulation, thinning intensity and yield prediction. As a corollary, if yield figures are available it can be used to assess the site quality of the plantation. The site quality of plantation based on top height can be compared with the site quality based on actual yields, grouping plantations by different types of work.

For each set of plantations under different types of work the site quality information based on top height is available either from the working plan or this study. Based on that information, percentage distribution of area in different site quality classes is presented in Table 3.9. It can be seen that most of the area of plantations both by area and number had a site quality of II or higher. There is no plantation in the lower classes of III/IV and IV.

Table : 3.7

Availability of information on site quality of teak plantation in Nilambur Divisions

Age class	Source of site quality information					
	Working plans[1]		KFRI[2]		Total	
	No of plantat-ions	Area (ha)	No of plantat-ions	Area (ha)	No of plantat-ions	Area (ha)
0 - 10	21	850.970	24	1059.722	45	1910.692
11 - 20	63	2698.904	19	766.274	82	3465.268
21 - 30	61	1919.966	2	97.200	63	2017.166
31 - 40	32	722.337	0	0.000	32	722.337
>41	70	1487.618	0	0.000	70	1487.618
Total	247	7679.885	45	1923.196	292	9603.081

Source : 1. Ranganathan (198l), Vasudevan (1971) and 2. Appendix : 7

Table 3.8

Number and area of plantations in Nilambur Divisions for which site quality is known

Type of work	No. of plantations	Area (ha.)
1M	15	507.711
2M	32	1497.681
1S	38	1618.710
2S	44	1849.058
3S	62	1995.310
4S	82	1674.783
FF	19	459.828
Total	292	9603.081

Source : Ranganathan (1981), Vasudevan (1971) and Appendix : 7

Table : 3.9
Distribution of area of teak plantations in Nilambur Divisions based on known site quality

Type of work	Percentage in different site qualities based on top height								Total
	I	I/II	II	II/III	III	III/IV	IV	Failure	
1M	18 (27)*	55 (47)	27 (27)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	100
2M	11 (9)	29 (25)	56 (63)	4 (3)	0 (0)	0 (0)	0 (0)	0 (0)	100
1S	14 (11)	14 (16)	72 (74)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	100
2S	3 (2)	16 (18)	69 (64)	8 (9)	5 (7)	0 (0)	0 (0)	0 (0)	100
3S	5 (6)	3 (5)	59 (53)	30 (29)	3 (6)	0 (0)	0 (0)	0 (0)	100
4S	1 (1)	29 (32)	63 (56)	8 (10)	0 (1)	0 (0)	0 (0)	0 (0)	100
FF	13 (11)	42 (37)	37 (37)	4 (11)	4 (5)	0 (0)	0 (0)	0 (0)	100

* Figures in parenthesis denote distribution based on number of plantations

Computed from Ranganathan (1981), Vasudevan (1971) and Appendix : 7

Table 3.10 relates to the same set of plantations as in Table 3.9 but gives the percentage distribution according to different site qualities based on actual yield obtained. Naturally, yields corresponding to the site quality given in the working plan are to be expected. It can be seen that when the actual yield is considered, the corresponding site quality distribution is skewed towards the site quality classes III/IV and IV. The lowest site quality class is IV. However, a substantial percentage of plantations has recorded yields lower than that of site quality IV. Yields which are lower than that expected for site quality IV are therefore indicated hereafter as

Table : 3.10

Distribution of area of teak plantations (having site quality information) according to site qualities based on actual yields obtained in Nilambur Divisions

Type of work	Percentage site qualities based on actual yield obtained								Total
	I	I/II	II	II/III	III	III/IV	IV	Failure	
1M	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	96 (93)	0 (0)	4 (7)	100
2M	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	14 (16)	59 (63)	28 (22)	100
1S	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (3)	49 (47)	50 (50)	100
2S	0 (0)	0 (0)	0 (0)	0 (0)	1 (2)	6 (9)	26 (41)	67 (48)	100
3S	4 (2)	0 (0)	50 (53)	6 (5)	0 (0)	7 (8)	14 (15)	19 (18)	100
4S	52 (66)	2 (4)	9 (7)	5 (4)	12 (10)	6 (2)	11 (4)	3 (4)	100
FF	0 (0)	0 (0)	10 (5)	0 (0)	12 (21)	5 (5)	22 (26)	51 (42)	100

* Figures in parenthesis denote distribution based on number of plantations

Computed from Ranganathan (1981) Vasudevan (1971) and Appendix : 7

Table 3.11 shows the site quality observed based on the mean yield of the entire data set as well as the mean in the lowest and highest decile in different operations. Overall, it can be seen that when the mean yield is considered the site quality obtained is only IV. The yield in the lowest decile represents a site quality far below the lowest class and is therefore shown as failure. Even the yield in the highest decile comes up to that expected in site quality class II/III only. Therefore, the best teak plantations in Nilambur which are famous for its teak show a productivity level lower than that of the expected yield in site quality I.

Table : 3.11
Average yield of teak plantations and site quality observed in Nilambur Divisions

Type of work	No.of Plant-ations	Total area (ha)	Mean age	Mean		Lowes decile		Highest decile	
				Yield (m^3ha^{-1})	S.Q.	Yield (m^3ha^{-1})	S.Q.	Yield (m^3ha^{-1})	S.Q.
1M	26	888.565	6	4.641	III/IV	1.172	Failure	10.434	III/IV
2M	43	1906.204	8	5.994	IV	2.365	Failure	11.459	III/IV
1S	57	2411.523	13	5.291	Failure	0.425	Failure	8.643	IV
2S	48	2082.508	19	4.917	Failure	0.159	Failure	10.989	III/IV
3S	65	2101.210	28	15.672	II/III	3.444	Failure	26.963	I/II
FT	86	1829.303	41	15.615	II	4.461	IV	26.029	I
FF	47	1316.844	53	99.128	III/IV	39.543	Failure	204.475	II
Total	372	12536.157		151.258	IV	51.569	Failure	298.992	II/III

Source : Results of productivity analysis

As the same set of plantations were used for comparing the site quality based on top height and site quality based on actual yields an identical distribution is expected. But the ,data obtained show that it is not so (Tables 3.9 and 3.10). While the site quality of plantations based on top height concentrated in the higher classes, the site quality based on actual yields is seen shifted to much lower classes. To examine this issue further, plantations having data on yield for more than one operation were sorted. Details regarding such 30 plantations are given in Table 3.12. Site qualiy based on top height and that based on actual yield obtained for the same plantation are compared in the Table. As was seen earlier, the site quality information available in the Working Plans cannot be relied upon to predict the yields in different operations. A general observation is that the site quality based on top height measured between the age of 10 and 20 does not hold good during later years and the thinning and final felling yields are far below that indicated by the site quality. In most of the plantations, a progressive deterioration in site quality

Table 3.12
Site qualities of selected plantations in Nilambur Divisions based on top height and yields

Plng. Year	Name of Plantation	S.Q. based on top height	Site Qualities based on actual yields obtained															
			1st Mech.		2nd Mech.		1st Silvi.		2nd Silvi.		3rd Silvi		4th Silvi.		Final	Felling
			Age	S.Q.	Age	S.Q.	Age	S.Q.	Age	S.Q.	Age	S.Q.	Age	S.Q.	Age	S.Q.
1934	Aravallikavu	1/11											40	I	56	Failure
1934	Mulathamanna	II/III											40	I	52	IV
1934	Nellikutha	II											40	II	54	IV
1938	Valluvasseri	II									29	ii	41	III	52	IV
1939	Vlluvasseri	III									30	II			52	Failure
1940	Valluvasseri	1/11									28	II			51	IV
1942	Valluvasseri	II									28	II	40	Failure		
1949	Old Amarampalam	III							18	IV	29	III/IV				
1949	Panangode	II							18	IV	29	Fatlure				
1951	Panangode	II							18	IV	28	IV				
1952	Valluvasseri	II/III							18	IV			**37**	Failure		
1953	Valluvasseri	II							18	IV			37	Failure		
1957	Edacode	II			**11**	Failure	12	IV	18	IV						
1959	Edacode	II					12	IV	19	Failure						
1960	Edacode	II			8	IV	12	IV	19	Failure						
1960	Ramallur	II			8	IV			19	Failure	27	Failure				
1961	Sankarancode	II			8	IV	12	IV			31	I				
1962	Mundakadavu	II			8	IV	13	Fatlure			28	Failure				
1963	Mundakadavu	II			8	IV	12	IV			26	Failure				
1964	Edacode	II	4	III/IV	8	IV	13	Failure								
1965	Edacode	II			8	IV	13	Failure								
1965	Ezhuthukal	II			10	Failure	13	Failure								
1970	Poolakkappara	1/11	5	III/IV	8	III/IV	12	Failure	22	Failure						
1971	Ezhuthukal	1/11	4	III/IV	8	III/IV			21	Failure						
1972	Poolakkappara	II	4	III/IV	8	III/IV	12	Failure	20	Failure						
1974	Nedumgayam	I	4	III/IV	8	Failure	12	Failure	19	Failure						
1975	Aravallikavu	1/11	5	III/IV	9	IV	13	Failure								
1976	Kanakutha	1/11	6	III/IV	8	III/IV	16	Failure								
1978	Kanakutha	I			8	Failure										
1979	Kanakutha	1/11	6	III/IV	10	Failure										

Source : For yield data - files of the Forest Department ; For site quality based on top height - Ranganathan Vasudevan (1971) and Appendix : 7

with increase in age can be seen. However, there are a couple of exceptions too. For 1934 Aravellikavu teak plantation, the site quality is given as 1/11. But the fourth silvicultural thinning at the age of 40 shows an yield equivalent to that of site quality I. This may be due to the skipping of the previous prescribed thinning. It is interesting to find that the final felling yield at the age of 56 from the same plantation reveals a site quality of less than IV which is classified as 'failure'. Similarly for 1961 Sankarancode teak plantation, the site quality according to the Working Plan is II. During the second mechanical thinning, the yield obtained was equivalent to that of site quality IV and during the first silvicultural thinning the yield was only that expected for site quality IV. Here again, during the third silvicultural thinning the yield was as much as that expected in site quality I. It is likely that the second silvicultural thinning has not been carried out and hence the yield obtained was the cumulative yield of two thinnings. Section 5 discusses this issue further.

4. PROFITABILITY OF TEAK PLANTATIONS

In this section, a financial cost benefit analysis is done for teak plantations in the government forests. Using the average costs and returns per ha, the results of the profitability analysis for plantations with mean, low and high yield are presented. All cost and benefits are estimated on the basis of 1995 current prices.

4.1. Cost of cultivation and valuation of outputs

Costs includes expenditure on planting, maintenance, thinning and final felling in different years. As plantations are raised in government forest lands no land costs are considered.Under the National Forest Policy, opportunities for other land uses such as agriculture or non-forest plantation crops do not exist in forests. Therefore no opportunity costs for land are included. Similar studies have also avoided valuation of opportunity costs of replacing natural forests with plantation (for eg. see Nair, 1977). Some public sector corporations which have already leased-in forest lands to raise rubber and other plantation crops are charged an annual land rent of Rs. 1300 per ha. The profitability analysis is carried out under three options: (1) without land rent, (2) with land rent of Rs. 1300/ha and (3) with land rent of Rs. 2500/ha.

There is certainly an opportunity cost in converting mixed natural forests into monoculture plantations. In the long run, due to removal of other species in weeding operations, biodiversity will be reduced. The timber, firewood and non-wood forest products that would have been available if the natural forests were managed on a sustainable basis would not be available from a teak plantation. Aesthetic value of a teak plantation is also lower than a

natural mixed forest. The wildlife habitat is also modified and its quality reduced by converting a natural forest tract into a teak monoculture. In spite of all these, the opportunity cost is not included in this study due to the fact that following the Forest Conservation Act 1980, no new plantations were raised after clearfelling natural forests. At present, natural forests are not used for raising teak plantations. Existing plantations continue to be managed as plantations in successive rotations.

An overhead charge of Rs. 358 ha^{-1} for all years is included in the analysis. This represented the cost of fire protection and administrative charges.

The different thinning and final felling costs represent the labour and other charges for extraction of timber. It was worked out from the total costs and mean yield obtained in each operation in selected plantations. The mean costs per m^3 was found out from the above. Using this, the average costs per m^3 of yield in different operations were worked out. To get the average cost per ha for plantations with mean, low and high yield, the average cost per m3 was multiplied by the respective yields.

The average price of teak for different girth and quality classes during 1995 is given in Table 4.1. Teak logs and poles are classified according to girth and quality classes. Appendix 3 gives the girth limits and quality specifications used by the Forest Department for timber and poles. The prices given in Table 4.1 are in Rs. per m^3 and do not refer to the number of logs or poles. A large number of poles are required to make up one m3. Appendix 8 gives the conversion factors in terms of number of poles equivalent to $1m^3$ of pales. For one m3 of teakwood the prices range from Rs. 2400 to 45,400. The difference is 15 times between the lowest and highest size class. Products

from younger plantations have a lower value than that of older plantations. Apart from logs and poles, the output includes teak billets and teak firewood. Billets are small pieces of teak with length of one metre or less. Firewood is branch wood having girth 30 to 60 cm over bark. These are used for marking electric switch boxes, photo frames etc and not used as fuel.

Table : 4.1
Average price of teak in different girth and quality classes during 1995

Item	Class	Quality	Unit	Price (Rs/unit)	Price (Rs /m^3)
Teaklog	E	A	M^3	45379	45379
Teaklog	E	B	M^3	42700	42700
Teaklog	I	A	M^3	35617	35617
Teaklog	I	B	M^3	34697	34697
Teaklog	I	C	M^3	28573	28573
Teaklog	II	A	M^3	25825	25825
Teaklog	II	B	M^3	25690	25690
Teaklog	II	C	M^3	22272	22272
Teaklog	III	A	M^3	23055	23055
Teaklog	III	B	M^3	22258	22258
Teaklog	III	C	M^3	17696	17696
Teaklog	IV	A	M^3	17373	17373
Teaklog	IV	B	M^3	17098	17098
Teaklog	IV	C	M^3	13136	13136
Teak billets			MT	4232	6510
Teak fire wood			MT	1675	2577
Teakpole	I	A	No.	3128	13138
Teakpole	I	B	No.	2355	9891
Teakpole	I	C	No.	2082	8744
Teakpole	II	A	No.	1486	12631
Teakpole	II	B	No.	1355	11519
Teakpole	II	C	No.	1217	10344
Teakpole	III		No.	611	8621
Teakpole	IV		No.	243	8593
Teakpole	V		No.	43	3018
Teakpole	VI		No.	17	2429

For valuing the output from thinning and final felling the mean yield is not sufficient as the price differences between different girth and quality classes of teakwood are very high. The mean distribution of yield by different girth and quality classes for each operation has been worked out. The distribution of yield from different types of work for Nilambur Divisions is presented in Appendix 9. The percentage distribution of the same for Nilambur Divisions is given in Appendix 10.

The benefits from a teak plantation are obtained from thinnings and final felling. For arriving at the benefit from each operation the break up of each item of output is multiplied with the corresponding price.

4.2. Profitability in Nilambur Divisions

Table 4.2 shows the average costs per ha for raising teak plantations in Nilambur Divisions with mean yield. During the initial year, a cost of Rs.2900 is incurred for land preparation, nursery, planting etc. The maintenance cost during the first and second year is Rs.3600 and during the third year it is Rs.1750. Up to the middle of 1980's the maintenance of p1antations during the first three years was entrusted to the taungya lessee who grew an agricultural crop among the teak plants. Accordingly, instead of the present cost, a revenue was obtained in the form of land rent. The taungya system which prevailed for over 50 years in Kerala was discontinued due to soil erosion etc. (Alexander *et al*,1980). For plantations with mean yield, the total costs with a rotation of 53 years is Rs. 1,05,000 ha^{-1}.

Table : 4.2

Cashflow from teak plantations in Nilambur Divisions with mean yield

Type of work	Age (Yr)	cost (Rs)	Benefit (Yr)	Net benefit (Rs)
Planting	0	2899.00	0.00	-2899.00
Maintenance	1	3663.00	0.00	-3663.00
Maintenance	2	3561.00	0.00	-3561.00
Maintenance	3	1753.00	0.00	-1753.00
	4	358.00	0.00	-358.00
Cultural operation	5	1640.00	0.00	-1640.00
1 Mech. thinning	6	3169.95	20036.99	16867.04
	7	358.00	0.00	-358.00
2 Mech. thinning	8	3005.77	41689.36	38683.59
	9	358.00	0.00	-358.00
Tending	10	2628.00	0.00	-2628.00
	11	358.00	0.00	-358.00
	12	358.00	0.00	-358.00
1 Silvi. thinning	13	2526.53	50724.80	48198.27
	14	358.00	0.00	-358.00
	15	358.00	0.00	-358.00
	16	358.00	0.00	-358.00
	17	358.00	0.00	-358.00
Weeding	18	1866.00	0.00	-1866.00
2 Silvi. thinning	19	3495.43	44650.89	41155.46
	20	358.00	0.00	-358.00
	21	358.00	0.00	-358.00
	22	358.00	0.00	-358.00
	23	358.00	0.00	-358.00
	24	358.00	0.00	-358.00
	25	358.00	0.00	-358.00
Weeding	26	1451.00	0.00	-1451.00
	27	358.00	0.00	-358.00
3 Silvi. thinning	28	9028.28	192356.87	183328.59
Loranthus cutting	29	1093.00	0.00	-1093.00
	30	358.00	0.00	-358.00
Climber cutting	31	462.00	0.00	-462.00
	32	358.00	0.00	-358.00
	33	358.00	0.00	-358.00

Type of work	Age (Yr)	Cost (Rs)	Benefit (Rs)	Net benefit (Rs)
	34	358.00	0.00	-358.00
	35	358.00	0.00	-358.00
	36	358.00	0.00	-358.00
	37	358.00	0.00	-358.00
	38	358.00	0.00	-358.00
	39	358.00	0.00	-358.00
	40	358.00	0.00	-358.00
4 Silvi. thinning	41	16951.09	228573.21	211622.12
Loranthus cutting	42	717.00	0.00	-717.00
	43	358.00	0.00	-358.00
	44	358.00	0.00	-358.00
	45	358.00	0.00	-358.00
	46	358.00	0.00	-358.00
	47	358.00	0.00	-358.00
	48	358.00	0.00	-358.00
	49	358.00	0.00	-358.00
	50	358.00	0.00	-358.00
	51	358.00	0.00	-358.00
	52	358.00	0.00	-358.00
Final felling	53	32339.57	1814431.91	1782092.34
Total		105137.62	2392464.03	2287326.41

The benefits range from Rs. 20,000 in the sixth vear to Rs. 2.28 lakhs during 4th silvicultural thinning in the 41st year. The find felling yield is Rs. 18 lakhs during the 53rd year. The total benefit is Rs. 24 lakhs.

The cash flow which is the net of benefits and costs is given in Table 4.2. It can be seen that the total net benefit at the end of 53 years is about Rs. 23 lakhs. It may be noted that with the first mechanical thinning in the sixth year, the benefits exceed the accumulated costs up to that vear. Although teak is a long rotation crop, the returns exceed the costs within a short period of six years. Previously, when taungya system was practised, the revenue exceeded the costs from the first year. Appendix 11 and 12 shows the cash

flow from teak plantations in Nilambur Divisions with low and high yields respectively.

Tables 4.3, 4.4 and 4.5 show the Net Present Value (NPV) and B/C ratio (BCR) at different discount rates and Internal Rate of Return (IRR) of teak plantations in Nilambur Divisions with land rent zero, Rs. 1300 and Rs. 2500 respectively. Four different discount rates 6, 9, 12 and 18 percent are used in the calculation of NPV and B/C Ratio.

Table : 4.3
NPV and B/C ratio at different discount rates and IRR of teak plantations in Nilambur Divisions without land rent

Yield m3/ha/yr		Discount rate								IRR (%)
		6%		9%		12%		18%		
		NPV	BCR	NPV	BCR	NPV	BCR	NPV	BCR	
Low	0.973	42	2.9	9	1.5	-1	1.0	-5	0.6	11.7
Mean	2.854	191	7.5	79	4.6	40	3.2	15	2.0	31.3
High	5.641	385	10.9	165	7.0	90	5.1	40	3.4	46.4

NPV - Net Present Value [in Rs '000] BCR - Benefit Cost Ratio
IRR - Internal Rate of Return

Table : 4.4

NPV and B/C ratio at different discount rates and IRR of teak plantations in Nilambur Divisions with land rent Rs. 1300

Yield m^3/ha/yr		Discount rate 6% NPV	6% BCR	9% NPV	9% BCR	12% NPV	12% BCR	18% NPV	18% BCR	IRR (%)
Low	0.973	20	1.5	-7	0.8	-13	0.5	-14	0.4	7.8
Mean	2.854	169	4.3	63	2.7	28	1.9	6	1.3	22.4
High	5.641	363	7.0	150	4.5	78	3.3	31	2.2	36.6

NPV - Net Present Value [in Rs '000] BCR - Benefit Cost Ratio
IRR - Internal Rate of Return

Table : 4.5

NPV and B/C ratio at different discount rates and IRR of teak plantations in Nilambur Divisions with land rent Rs. 2500

Yield m^3/ha/yr		Discount rate 6% NPV	6% BCR	9% NPV	9% BCR	12% NPV	12% BCR	18% NPV	18% BCR	IRR (%)
Low	0.773	0	1.0	-21	*0.6*	-24	0.4	-22	0.3	6.0
Mean	2.854	149	3.1	49	1.9	17	1.4	-2	0.7	16.7
High	5.641	343	5.2	135	3.3	67	2.5	23	1.7	30.1

NPV - Net Present Value [in Rs '000] BCR - Benefit Cost Ratio
IRR - Internal Rate of Return

For the mean yield, the NPV declines from Rs.1,91,000 at 6% discount rate to Rs. 15,000 at 18% discount rates. The BCR also declines from 7.5 to 2. For the mean yield, IRR is 31.3%. This means that average profitability of teak plantation is 3l% when land rent is not taken into account. Even for plantations with low yield, the IRR is 11.7 % When a land rent of Rs.

$ha^{-1}year^{-1}$ is considered, the profitability of plantations with low yield is 7.8% (Table 4.4). Even with a higher land rent of Rs. 2500, the profitability of plantations with low yield is 6% (Table 4.5). Using B/C ratio as a criterion, discount rates higher than 12% brings down the B/C ratio to less than 1 for low yield when no land rent is considered. When a land rent above Rs.1300 is considered, a discount rate above 6% brings down the B/C ratio to less than unity for low yield. When mean yield is considered, the B/C ratio becomes less than 1 only at a discount rate of l8% with a land rent of Rs.2500.

Table 4.6 shows the maximum land rent possible in Nilambur Divisions under different discount rates. At 12% discount rate, if a high yield is obtained the maximum land rent possible is Rs. 9750 $ha^{-1}year^{-1}$ If the yield is low, no land rent can be paid at a discount rate of 12%. The term land rent is used not in a narrow sense. It only denotes the potential surplus considering the current cost, yield and benefit. If any of them changes, the surplus will also change. This also indicates the maximum money available for higher inputs if needed.

Table : 4.6
Maximum land rent possible in Nilambur Divisions for teak plantations under different discount rates

Yield level	Discount rates			
	6%	9%	12%	18%
Low	2500	750	-70	-790
Mean	11500	6750	4500	2250
High	23000	14000	9750	6250

5. DISCUSSION

In this section, a further discussion on the changes in productivity in teak plantations is made. As profitability depends on productivity, the discussion is limited to productivity.

5.1 Changes in productivity

For studying the changes in productivity in a crop which takes more than 50 years to mature, it is ideal to get the yield data from the same area in successive rotations. As this is not currently available, using cross-sectional data an attempt has been made here to look at the changes in productivity over time. Table 5.1 shows the distribution of area of teak plantations according to year of planting in Nilambur Divisions classified in different site qualities based on' actual yields. Plantations are grouped at five year intends based on the year of planting sequentially and the mean site quality based on vield obtained is shown as a percentage.

Table : 5.1

Percentage distribution of area of teak plantations according to year of planting in Nilambur Divisions classified in different site qualities based on actual yields

Type of work	Plantation year	No. of plantations	Area (ha.)	Site quality				
				I	II	III	IV	Failure
1M	1960 - 64	3	30.600	0	0	0	80	20
	1970 - 74	6	264.247	0	0	0	100	0
	1975 - 79	8	263.920	0	0	0	100	0
	1980 - 84	6	175.056	0	0	0	47	53
	1985 - 89	3	94.742	0	0	0	69	31
2M	1955 - 59	2	94.700	0	0	0	0	100
	1960 - 64	15	628.400	0	0	0	100	0
	1965 - 69	4	203.540	0	0	0	62	38
	1970 - 74	5	249.42'1	0	0	0	81	'19
	1975 - 79	12	572.969	0	0	5	47	48
	1980 - 84	5	157.174	0	0	0	29	71
1S	1955 - 59	11	497.100	0	0	0	100	0
	1960 - 64	15	731.763	0	0	0	82	18
	1965 - 69	5	173.950	0	0	0	13	87
	1970 - 74	10	400.777	0	0	0	0	100
	1975 - 79	8	279.810	0	0	0	20	80
	1980 - 84	8	328.123	0	0	0	0	100
2S	1945 - 49	4	67.500	0	0	0	45	55
	1950 - 54	15	436.904	0	0	0	69	31
	1955 - 59	13	598.327	0	0	0	62	38
	1960 - 64	2	466.000	0	0	0	0	100
	1965 - 69	4	113.250	0	0	0	53	47
	1970 - 74	9	395.027	0	0	6	0	94
3S	1935 - 39	13	339.100	0	95	5	0	0
	1940 - 44	16	528.200	0	67	21	12	0
	1945 - 49	20	605.710	0	53	12	25	10
	1950 - 54	4	92.230	0	0	0	88	12
	1960 - 64	11	505.970	15	0	0	24	61
4S	1930 - 34	20	365.800	91	7	1	0	0
	1935 - 39	19	654.480	21	15	21	44	0
	1940 - 44	2	74.980	0	0	70	0	30
	1950 - 54	5	125.903	0	0	3	70	27
FF	1930 - 34	7	135.237	0	0	0	26	74
	1935 - 39	7	127.246	0	0	6	38	55
	1940 - 44	8	143.958	0	7	14	70	9

Different thinning operations are considered separately. In each set of operations, a distinct shift from better to poorer site quality class over time can be seen. In the third silvicultural thinning (3S) while the yield from 13 plantations raised during 1935-39 reflected a site quality of II by 1950-54 the yields from 4 plantations showed a site quality of only IV and during the period 1960-64, 61% of the area of plantations shifted further to the 'failure' class. Only in the final felling category, there is a slight improvement but here the difference between the year of planting is only 10 years i.e. between 1930-34 and 1940-44. Plantations raised in the subsequent years will be available for final felling only after 1995. In the fourth silvicultural thinning (4S), 91% of the 20 plantations that were planted during the period 1930-34 showed a site quality class of I. By 1940-44 no plantations belonged to either site quality I or even II. Plantations raised in the period 1950-54 showed a mean site quality of IV. Although no definitive conclusions can be made, the general indication is that there has been a decline in the productivity level in successive periods as observed in the thinning yields of plantations.

Another exercise was done using the period of working as a criterion for observing the changes in productivity levels. Table 5.2 shows the percentage distribution of area of teak plantations in Nilambur Divisions based on year of working classified in different site qualities based on actual yields. It is interesting to find that within each thinning operation, the site quality distribution considered on the basis of actual yield showed a shift from higher to lower classes in successive periods of operation. For example, while 26% of the plantations that were taken up for final felling during the period 1970-74 belonged to site quality II and 26% belonged to site qualitv III. During 1990-94, 57% of the area of plantations finally felled belonged to site quality IV and 31% came in the 'failure' category.

Table : 5.2

Percentage distribution of area of teak plantations according to year of working in Nilambur Divisions classified in different site qualities based on actual yields

Type of work	Year of working	No. of planta-tions.	Area (ha)	Site quality				
				I	II	III	IV	Failure
1M	1965 - 69	3	90.600	0	0	0	80	20
	1975 - 79	6	264.247	0	0	0	100	0
	1980 - 84	7	178.220	0	0	0	100	0
	1985 - 89	5	180.976	0	0	0	81	19
	1990 - 94	5	174.522	0	0	0	50	50
2M	1965 - 69	9	355.060	0	0	0	73	27
	1970 - 74	11	494.880	0	0	0	100	0
	1975 - 79	3	173.900	0	0	0	56	44
	1980 - 84	5	215.641	0	0	0	78	22
	1985 - 89	14	609.003	0	0	5	41	54
	1990 - 94	1	57.720	0	0	0	0	100
1S	1965 - 69	7	291.200	0	0	0	100	0
	1970 - 74	11	546.800	0	0	0	100	0
	1975 - 79	11	513.763	0	0	0	55	45
	1980 - 84	4	143.262	0	0	0	0	100
	1985 - 89	9	330.935	0	0	0	0	100
	1990 - 94	15	585.563	0	0	0	10	90
2S	1965 - 69	11	236.304	0	0	0	54	46
	1970 - 74	11	371.500	0	0	0	83	17
	1975 - 79	12	960.927	0	0	0	28	72
	1985 - 89	5	135.500	0	0	16	44	39
	1990 - 94	9	378.277	0	0	0	0	100
3S	1965 - 69	18	496.200	0	72	15	12	0
	1970 - 74	17	566.800	0	76	22	2	0
	1975 - 79	18	502.240	0	42	0	44	14
	1985 - 89	7	305.205	0	0	10	40	51
	1990 - 94	5	230.765	33	0	0	0	67
4S	1965 - 69	35	509.800	85	4	10	0	0
	1970 - 74	23	434.800	85	14	1	0	0
	1975 - 79	19	592.680	24	16	23	37	0
	1980 - 84	3	142.980	0	0	37	48	16
	1985 - 89	4	115.660	0	0	4	76	21
	1990 - 94	2	33.383	0	0	69	0	31
FF	1970 - 74	9	350.219	0	26	34	26	13
	1975 - 79	13	476.789	0	0	22	43	36
	1980 - 84	5	126.405	0	0	11	66	23
	1985 - 89	10	193.446	0	5	4	34	57
	1990 - 94	10	169.985	0	0	12	57	31

The above two Tables indicate a decline in productivity in successive periods in all operations without considering the year of planting. Can this mean a decline in management effectiveness over time? The data was insufficient to answer the question either way. But the possibility of such an eventuality cannot be ruled out. Nevertheless, considering the low levels of productivity achieved in Nilambur Divisions, it is very essential to give more importance to efforts for increasing the productivity of teak plantations by enhancing the quality of management inputs.

It would have been ideal if the productivity level remained stable and closely related to the site quality of each pltintation as determined from the top height. In that case, a more refined method of fixing the economically optimum rotation for each site quality was possible. Table 3.12 showed high variability between the site quality of plantations and the level of yield obtained in different operation in selected plantations. Even among the different operations in the same plantation there was marked variation in yield. In this situation an exercise in proposing a rotation age based on the site quality is meaningless.

The primary requirement is to find out the reasons for the low productivity and the variation in yield levels. It is beyond the scope of this study to address this problem. Remedial measures will necessarily have to be based on the causes for the low yields. Manipulation of the rotation age and its associated change in thinning schedule without a detailed management evaluation will only complicate matters. Till such a time, the current thinning schedule and rotation age should best continue unchanged.

Table : 5.5

Sensitivity analysis of teak plantations in Nilambur with land rent Rs.2500 while cost of plantation increased by 100% and price of teak remaining the same

Yield $m^3 ha^{-1} yr^{-1}$		Discount rate								IRR (%)
		6%		9%		12%		18%		
		NPV	BCR	NPV	BCR	NPV	BCR	NPV	BCR	
Low	0.973	-22	1.0	-39	0.6	-39	0.4	-34	0.3	4.8
Mean	2.854	119	3.1	27	1.9	-1	1.4	-16	0.9	11.9
High	5.641	304	5.2	108	3.3	45	2.5	7	1.7	20.6

NPV - Net Present Value [in Rs '000] BCR - Benefit Cost Ratio

IRR - Internal Rate of Return

Table : 5.6

Maximum Land Rent possible for teak plantations in Nilambur under different discount rates with cost of plantation increased by 100% and price of teak remaining the same

(Rs ha^{-1})

Yield $m^3 ha^{-1} yr^{-1}$		Discount rates			
		6%	9%	12%	18%
Low	0.973	1250	-730	-1700	-2700
Mean	2.854	9750	5000	2500	250
High	5.641	20500	11500	7500	3750

6. CONCLUSIONS

Teak is a valuable multipurpose timber naturally found in the forests of Kerala. The first teak plantation in India was started in Nilambur in 1842. Since then there has been a continuous expansion of teak plantations in forests. In this study, productivity and profitability in teak plantations in Nilambur Divisions were analysed. The results and conclusions are summarised here.

The study revealed that the mean total yield from teak plantations in Nilambur was 151.257 $m^3 ha^{-1}$ and the mean annual increment(MAI) during a rotation of 53 years was 2.854 $m^3 ha^{-1} year^{-1}$ during the period 1967 to 1994.

For plantations in site quality class I, the expected MAI at 53 years is 9.84 $m^3 ha^{-1} year^{-1}$ and for site quality IV plantation, it is 2.13 $m3 ha^{-1} year^{-1}$ according to the All India Yield Tables for teak. The MAI obtained is equivalent to the yield expected in site quality class IV. The plantations with yield in the lowest decile has a site quality class far below the lowest class. Even the plantations with yield in the highest decile had only the site quality class of II/III. Therefore, the best teak plantations in Nilambur which were famous for its teak showed a productivity level far below the expected yield in site quality class I.

The fmancial cost benefit analysis of teak plantations in Nilambur Divisions showed that for the mean yield, the net present value (NPV) ranged from Rs.1,91,000 at 6% discount rate to Rs. 15,000 at 18% discount rate. The benefit cost ratio (BCR) ranged from 7.5 to 2 at 6 and 18% rate of discount. For the mean yield, internal rate of return

average profitability of teak plantation was 31.3% when land rent has not been taken into account. Even for plantations having low yield, the IRR mas 11.7 % When a land rent of Rs. 1300 ha^{-1} $year^{-1}$ is considered, the profitability of plantations having low vield was 7.8%. And with a higher land rent of Rs. 2500, it was 6.0%. Using BCR as a criterion, discount rates higher than 12% brought down the BCR to less than 1 for low yield when no land rent was considered. When a land rent of Rs.1300 was considered, a discount rate above 6% brought down the BCR to less than unity for low yield. When mean yield is considered, the BCR becomes less than 1 onlv at a discount rate of 18% with a land rent of Rs.2500. At 12% discount rate, if a high yield is obtained, the maximum land rent possible is Rs.9750 ha^{-1} $year^{-1}$. If the yield is low, no land rent can be paid at a discount rate of 12% The term land rent is used to denote the potential surplus considering the current cost, yield and benefit. This also indicate the maximum money available for higher inputs if needed.

The productivity achieved in Nilambur teak plantations was much below the potential productivity as indicated in the All India Yield Tables. Even then, the plantations are profitable to the government. With better management inputs, it is possible to increase the productivity in Nilambur teak plantations at least to the level indicated by the site quality of each plantation. For this, yield class assessment have to periodically be carried out instead of mere site quality determination once in a rotation, based on top height.

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APPENDICES

Appendix : 1

Data on yield from teak plantations in Nilambur Divisions used for the analysis

Division & Range	Plant Year	Name of Plantation	Area (ha.)	Yield in different type of operation: (m³)						
				1M	2M	1S	2S	3S	4S	FF
Nilambur North										
Edavanna	1968	Edacode	23.250				75.611			
Edavanna	1978	Edacode	143.720			1143.741				
Nilambur	1915	Aravallikavu	22.370							2565.959
Nilambur	1917	Kanakutha	10.050							2484.731
Nilambur	1919	Kanakutha	85.700							5634.771
Nilambur	1920	Valluvasseri	14. 144							2113.176
Nilambur	1923	Edacode	10.300						203.373	
Nilambur	1923	Kanakutha	10.500						286.317	
Nilambur	I924	Edacode	3.800						74.942	
Nilambur	I924	Valluvasseri	7.700						152.330	
Nilambur	1925	Aruvacode	0.800						133.178	
Nilambur	1925	Edacode	8.400						165.080	
Nilambur	1925	Mulathamanna	13.200						259.982	
Nilambur	I925	Valluvasseri	8.300						163.496	
Nilambur	1926	Edacode	4.000						79.754	
Nilambur	1926	Old Amarampalam	7.000						132.558	
Nilambur	1926	Ramallur	2.400						47.055	
Nilambur	I927	Aruvacode	5.100						98.338	
Nilambur	1927	Edacode	30.000						591.775	
Nilambur	1927	Elanjeri	15..500						306.255	
Nilambur	I927	Mulathamanna	5.300						109.252	

Division &. Range	Plant Year	Name of Plantation	Area (ha.)	Yield in different type of operations (m^3)						
				1M	2M	1S	2S	3S	4S	FF
Nilambur	I927	Ramallur	5.900						116.411	
Nilambur	1928	Edacode	10.200						318.219	
Nilambur	1929	Edacode	13.000						256.092	
Nilambur	I929	Elanjeri	8.400						166.280	
Nilambur	1929	Erampadam	18.900						372.427	
Nilambur	1930	Elanjeri	19.400						381.995	
Nilambur	1930	Nellikutha	53.300						1050.350	
Nilambur	1930	Old Amarampalam	2.000						39.082	
Nilambur	1931	Edacode	0.200						122.025	
Nilambur	1931	Nellikutha	77.400						1525.696	
Nilambur	1931	Panangode	14.400						283.924	
Nilambur	1932	Nellikutha	46.964						910.791	1636.227
Nilambur	1932	Panayangode	24.500						482.513	
Nilambur	1933	Edacode	1.100						21.535	
Nilambur	1933	Elanjeri	3.900						90.903	
Nilambur	1933	Nellikutha	25.425						590.560	1691.024
Nilambur	1933	Panangode	10.400						204.969	
Nilambur	1934	Aravallikavu	6.761						131595	305.260
Nilambur	1934	Mulathamanna	4.737						93.314	402.036
Nilambur	1934	Panangode	6.200						138.263	
Nilambur	1935	Aravallikavu	11.780						258.403	337.180
Nilambur	1935	Edacode	17.500						345.336	
Nilambur	I935	Nellikutha	24.737						488.894	840.482
Nilambur	1936	Edacode	35.900						416.563	
Nilambur	1936	Nellikutha	27.900						254.247	
Nilambur	I937	Edacode	19.000					407.301		

Division & Range	Plant Year	Name of Plantation	Area (ha.)	Yield in different type of operations (m^3)						
				1 M	2M	1 S	2 S	3S	4S	FF
Nilambur	1937	Nellikutha	36.800					788.603		
Nilambur	1937	Panangode	13.300					285.110	214.534	
Nilambur	1937	Pannyangode	13.320							690.870
Nilambur	1937	Valluvasseri	8.057					172.453	647.737	940.599
Nilambur	1938	Nellikutha	74.100					1587.600	423.183	
Nilambur	1938	Pokkode	2.300					50.203	38.413	
Nilambur	1938	Valluvasseri	18.745					401.235	223.181	1620.772
Nilambur	1939	Erampadam	12.090					276.445	210.038	
Nilambur	1939	Panangode	27.800					568.255		
Nilnmbur	1939	Valluvasseri	20.607					438.384		877.930
Nilambur	1940	Val1uvasseri	22.794					203.892		1800.090
Nilambur	1941	Valluvasseri	9.200					197.557		
Nilambur	1942	Valluvasseri	22.338					548.556	68.793	1745.551
Nilambur	1943	Chathambora	20.400					435.898		
Nilambur	1943	Elanjeri	3.700					78.860		
Nilambur	1943	Nellikutha	36.500					781.654		
Nilambur	I943	Valluvasseri	52.632					1140.442	578.697	
Nilambur	1944	Chathambora	40.900					87.5.263		
Nilambur	1944	Old Amarampalam	8.700					185.452		
Nilambur	1945	Chathambora	25.100					537.290		
Nilambur	1945	Old Amarampalam	8.200					175.053		
Nilambur	1946	Chathambora	21.000					449.737		
Nilambur	1946	Old Amarampalam	11.600					74.614		
Nilambur	1947	Chathambora	25.200					539.890		
Nilambur	1947	Old Amarampalam	29.100					623.950		
Nilambur	1948	Chathambora	7.500					00.276		

Division & Range	Plant Year	Name of Plantation	Area (ha.)	Yield in different type of operations (m^3)						
				1M	2M	1S	2S	3S	4S	FF
Nilambur	1948	Panangode	10.000					85.917		
Nilambur	1949	Churulipotty	42.000					257.734		
Nilambur	1949	Panangode	17.200				55.213	34.105		
Nilambur	1950	Panangode	11.070					48.016		
Nilambur	1951	Panangode	10.400				88.944	58.111		
Nilambur	1952	Panangode	8.100				68.605			
Nilambur	1952	Panayangode	4.130						52.147	
Nilambur	1952	Valluvasseri	23.810				179.250		66.664	
Nilambur	1953	Pokkode	28.300				156.169			
Nilambur	1953	Valluvasseri	10.243				90.668		23.482	
Nilambur	1954	Valluvasseri	21.300				180.983			
Nilambur	1955	Pokkode	23.140		149.957		165.133		243.809	
Nilambur	1956	Edacode	24.200		187.185		205.885			
Nilambur	1957	Edacode	36.000		496.506	258.457	546.763			
Nilambur	1957	Nellikutha	3.400		29.735		28.655			
Nilambur	1958	Edacode	43.100		333.407		367.097			
Nilambur	1959	Edacode	48.100		372.225		130.619			
Nilambur	1960	Edacode	19.020		186.584	106.916	79.728			
Nilambur	1961	Edacode	18.210	40.844	140.876	102.367				
Nilambur	1963	Edacode	52.410		397.584	288.902				
Nilambur	1964	Edacode	25.300	42.720	104.491	142.176				
Nilambur	1965	Edacode	22. 550		49.915	126.929				
Nilambur	1966	Edacode	23.400		66,022					
Nilambur	1967	Kallenthode	27.650		163.503					
Nilambur	1974	Karienmurien	48.000		115.190					
Nilambur	1975	Aravallikavu	22.370	29.449	76.902	192.077				

Division & Range	Plant Year	Name of Plantation	Area (ha)	Yield in different type of operations (m^3)						
				1M	2M	1S	2S	3S	4S	FF
Nilambur	1976	Kanakutha	43.050	178.669	101.386	270.933				
Nilambur	1977	Kanakutha	16.050	163.744		137.877				
Nilambur	1978	Kanakutha	82.050			253.616				
Nilambur	1979	Kanakutha	85.700	2'50.224		239.638				
Vazhikadavu	1934	Nellikutha	8.340						387.079	686.851
Vazhikadavu	1972	Karianmurien	49.780				5.475			
Vazhikadavu	1973	Karianmurien	58.750				111.151			
Vazhikadavu	1974	Karianmurian	51.430		191.679					
Vazhikadavu	1976	Karianmurien	58.750		58.846					
Nilambur South										
Karulai	1912	Poolakkappara	47.912							10815.435
Karulai	1914	Mundakadavu	14.826							2308.257
Karulai	1914	Nedumgayam	46.559							
Karulai	1923	Karimpuzha	22.800						336.039	
Karulai	1924	Karimpuzha	6.000						117.228	
Karulai	1924	New Amarampalam	22.800						449.015	
Karulai	1925	Karimpuzha	20.200						641.970	
Karulai	1926	Karimpuzha	30.400						599.739	
Karulai	1926	New Amarampalam	23.600						464.009	
Karulai	1927	Karimpuzha	9.400						185.029	
Karulai	1928	New Amarampalam	27.600						543.113	
Karulai	1929	New Amarampalam	34.900						648.377	
Karulai	1930	Krimpuzha	4.900						52.265	
Karulai	1931	Karimpuzha	8.500						167.483	
Karulai	1935	New Amarampalam	15.500						304.600	
Karulai	1936	New Amarampalam	13.090						211.838	

Division& Range	Plant Year	Name of Plantation	Area (ha.)	Yield in different type of operation: m^3)						
				1M	2M	1S	2S	3S	4S	FF
Karulai	1937	New Amarampalam	16.800					287.502	223.587	
Karulai	1939	New Amarampalam	68.100					1458.483	391.269	
Karulai	1940	New Amarampalam	38.600					340.642		
Karulai	1941	New Amarampalam	60.000					1023.514		
Karulai	1942	New Amarampalam	50.000					989.863		
Karulai	1943	New Amarampalam	69.900					1495.747		
Karulai	1944	Karimpuzha	59.300					1268.698		
Karulai	1945	New Amarampalam	56.700					1213.236		
Karulai	1947	New Amarampalam	55.900					1196.662		
Karulai	1948		56.200					1201.894		
Karulai	1948	Old Amarampalam	11.900					60.189		
Karulai	1948	Padukka	56.010					371.405		
Karulai	1949	Karimpuzha	29.000				45.750			
Karulai	1949	Old Amarampalam	12.500				111.354	111.410		
Karulai	1949	Padukka	15.000					370.985		
Karulai	1950	New Amarampalam	7.900				109.472			
Karulai	1950	Old Amarampalam	11.776				55.363	70.695		
Karulai	1950	Padukka	59.030				303.138	431.517		
Karulai	1951	New Amarampalam	57.700				686.588			
Karulai	1952	New Amarampalam	64.300				547.771			
Karulai	1953	New Amarampalam	61.600				112.525			
Karulai	1954	New Amarampalam	62.800				535.043			
Karulai	1955	New Amarampalam	61.100		472.092					
Karulai	1958	Padukka	57.030				234.518			
Karulai	1959	Pulimunda	57.500				322.393			
Karulai	1960	Pulimunda	66.640					346.362		
Karulai	1960	Ramallur	8.160			28.652	37.102	42.080		

Division &Range	Plant Year	Name of Plantation	Area (ha)	Yield in different type of operation (m^3)						
				1M	2M	1S	2S	3S	4S	FF
Karulai	1961	Ezhuthukal	55.749					669.935		
Karulai	1961	Mundakadavu	47.085	371.918	339.668	264.561		173.581		
Karulai	1961	Sankarancode	75.344		599.507	423.344		2693.435		
Karulai	1962	Ezhuthukal	64.980		467.849	363.294		406.439		
Karulai	1962	Mundakadavu	42.753		330.591	240.210		140.920		
Karulai	1963	Ezhuthukal	55.700		431.081	313.242				
Karulai	1963	Mundakadavu	32.591		252.012	183.144		134.995		
Karulai	1963	Sankarancode	18.660					55.353		
Karulai	1964	Ezhuthukal	64.818		407.132	361.696		352.473		
Karulai	1964	Mundakadavu	29.190			174.479		137.887		
Karulai	1965	Ezhuthukal	76.720		16.491	431.078				
Karulai	1965	Mundakadavu	27.570			154.915				
Karulai	1968	Ezhuthukal	30.000				317.449			
Karulai	1968	Kallenthode	30.000				263.317			
Karulai	1969	Poolakkappara	30.000				180.111			
Karulai	1970	Poolakkappara	44.300	223.725	103.669	410.848	154.226			
Karulai	1971	Cherupuzha	22.250				355.964			
Karulai	1971	Ezhuthukal	52.900	134.561		383.737	227.886			
Karulai	1972	Poolakkappara	47.912	558.074	277.797	514.415	273.807			
Karulai	1974	Mundakadavu	14.826	82.868	29.459		67.968			
Karulai	1974	Nedumgayam	46.559	230.760	35.440	167.686	104.517			
Karulai	1975	Mundakadavu	5.500				6.683			
Karulai	1978	Nedumgayam	30.000			70.326				
Karulai	1978	Pulimunda	30.000			192.158				
Karulai	1979	Ingar	9.500	65.674	188.847					
Karulai	1980	Ingar	19.500		91.616					
Karulai	1980	Kadannakappu	96.000		131.483					

Appendix : 2
Division-wise distribution of teak plantations covered

Division	No. of Plantations								Area (ha)
	1M	2M	1S	2S	3S	4S	FF	Total	
Nilambur North	12	19	26	23	36	63	29	208	5703.996
Nilambur South	14	24	31	25	29	23	21	167	6969.876
Total	26	43	57	48	65	86	50	375	12673.872

Appendix : 3
Criteria for classification of teak timber and teak poles

Timber class	Girth limits (in cm)	Length (in cm)	Quality		
			A	B	C
E	>180	>3	Straight and without any defects	Slightly bend without defects	Crooked with hollows or nodes
I	150-180	>3			
II	100-149	>3			
III	76-99	>3			
IV	60-75	>3			

Pole class	Girthlimits (in cm)	Length (in m)			
		A	B	C	D
I	(65-75)	>12	9-12	6-9	3-6
II	(53-64)	>12	9-12	6-9	3-6
III	(41-52)	-	-	>6	-
IV	(28-40)	-	-	-	>6
V	(15-27)	-	-	-	<6

Appendix : 4
Age limits considered for different type of work

Type of work	Nilambur Division					
	1967-81		1982-94		1967-94	
	Min.	Max.	Min.	Mas.	Min.	Max.
1M	4	7	4	7	4	7
2M	8	11	8	10	8	11
1S	12	13	12	16	12	16
2S	18	19	18	22	18	22
3S	28	*30*	26	31	26	31
4S	40	44	35	40	35	44
FF .	50	60	47	56	47	60

Appendix : 5

Expected yields from thinnings in teak plantations in different Site qualities

Age	Site quality						
	I	I/II	II	II/III	III	III/IV	IV
4	19.66	18.75	17.14	15.46	13.43	0.00	0.00
5	20.99	19.94	18.19	16.09	13.64	0.00	0.00
6	22.32	21.13	19.24	16.72	13.85	2.17	1.47
7	23.65	22.32	20.29	17.35	14.06	4.34	2.94
8	24.98	23.51	21.34	17.98	14.27	6.51	4.41
9	26.31	24.70	22.39	18.61	14.48	8.68	5.88
10	27.64	25.89	23.44	19.24	14.69	10.85	7.35
11	28.20	26.31	23.72	19.38	14.76	10.78	7.28
12	28.76	26.73	24.00	19.52	14.83	10.71	7.21
13	29.32	27.15	24.28	19.66	14.90	10.64	7.14
14	29.88	27.57	24.56	19.80	14.97	10.57	7.07
15	30.44	27.99	24.84	19.94	15.04	10.50	7.00
16	31.84	28.69	24.91	19.73	14.83	10.36	6.86
17	33.24	29.39	24.98	1952	14.62	10.22	6.72
18	34.64	30.09	25.05	19.31	14.41	10.08	6.58
19	36.04	30.79	25.12	19.10	14.20	9.94	6.44
20	37.44	31.49	25.19	18.89	13.99	9.80	6.30
21	37.44	31.56	24.98	18.54	13.85	9.66	6.16
22	37.44	31.63	24.77	18.19	13.71	9.52	6.02
23	37.44	31.70	24.56	17.84	13.57	9.38	5.88
24	37.44	31.77	24.35	17.49	13.43	9.24	5.74
25	37.44	31.84	24.14	17.14	13.29	9.10	5.60
26	35.48	30.16	23.16	16.51	13.01	8.96	5.46
27	33.52	28.48	22.18	15.88	12.73	8.82	5.32
28	31.56	26.80	21.20	15.25	12.46	8.68	5.18
29	29.60	25.12	20.22	14.62	12.18	8.54	5.04
30	27.64	23.44	19.24	13.99	11.90	8.40	4.90
31	26.73	22.81	18.89	13.92	11.55	8.19	4.76
32	25.82	22.18	18.54	13.85	11.20	7.98	4.62
33	24.91	21.55	18.19	13.78	10.85	7.77	4.48
34	24.00	20.92	17.84	13.71	10.50	7.56	4.34
35	23.09	20.29	17.49	13.64	10.15	7.35	4.20
36	22.39	19.73	17.00	13.36	10.01	7.21	4.06
37	21.69	19.17	16.51	13.08	9.87	7.07	3.92
38	20.99	18.61	16.02	12.80	9.73	6.93	3.78
39	20.29	18.05	15.53	12.53	9.59	6.79	3.64
40	19.59	17.49	15.04	12.25	9.45	6.65	3.50
41	18.96	16.93	14.62	12.04	9.31	6.51	3.43
42	18.33	16.37	14.20	11.83	9.17	6.37	3.36
43	17.70	15.81	13.78	11.62	9.03	6.23	3.29
44	17.07	15.25	13.36	11.41	8.89	6.09	3.22
45	16.44	14.69	12.94	11.20	8.75	5.95	3.15

Source : Tewari 1992

Appendix : 6

Expected yields frotn final felling in teak plantations in different Site qualities

Age	Site quality						
	I	I/II	II	II/III	III	III/IV	IV
40	211.32	176.33	144.49	122.10	98.31	78.02	38.08
41	216.14	179.97	147.57	123.43	99.43	79.00	58.71
42	220.97	183.61	150.65	124.76	100.55	79.98	59.34
43	225.80	187.25	153.73	126.09	101.67	80.76	39.97
44	230.63	190.88	156.81	127.42	102.79	81.94	60.60
45	233.46	194.52	159.89	128.75	103.91	82.92	61.23
46	240.21	198.58	162.69	130.57	105.03	83.97	62.14
47	244.97	202.64	165.48	132.39	106.15	85.02	63.05
48	249.73	206.70	168.28	134.21	107.27	86.07	63.95
49	254.49	210.76	172.08	136.03	108.39	87.12	64.86
50	259.25	214.81	173.88	137.85	109.51	88.17	65.77
51	263.38	218.45	176.89	140.15	110.91	88.86	66.75
52	267.50	222.09	179.90	142.46	112.31	89.56	67.73
53	271.63	225.73	182.91	144.77	113.70	90.26	68.71
54	275.76	229.37	185.92	147.08	115.10	90.96	69.69
55	279.89	233.01	188.93	149.39	116.50	91.66	70.67
56	283.53	236.44	192.14	151.98	118.25	92.85	71.58
57	287.17	239.87	195.36	154.57	120.00	94.04	72.49
58	290.80	243.29	198.58	157.16	121.75	95.23	73.40
59	294.44	246.72	201.80	159.75	123.50	96.42	74.31
60	278.08	250.15	205.02	162.34	125.25	97.61	75.22
61	301.65	253.16	207.68	164.78	127.35	98.73	76.41
62	305.22	256.17	210.34	167.23	129.45	99.85	77.60
63	308.79	259.18	213.00	169.68	131.55	100.97	78.79
64	312.36	262.19	215.65	172.13	133.65	102.09	79.98
65	315.92	265.20	218.31	174.58	135.75	103.21	81.17
66	318.79	268.13	220.83	177.45	137.92	104.96	82.36
67	321.66	271.07	223.35	180.32	140.08	106.71	83.55
68	324.53	274.01	225.87	183.19	142.25	108.46	84.74
69	327.40	276.95	228.39	186.06	144.42	110.21	85.93
70	330.27	279.89	230.91	188.93	146.59	111.96	87.12

Source Tewari 1992

Appendix : 7

List of plantations for which site quality was determined by KFRI during 1995

Year	and name of plantation	Species	Area (ha.)	Site quality
Edavanna Range				
1967	Edacode	Teak	20.040	II/III
1968	Edacode	Teak	23.250	II
1969	Edacode	Teak	55.900	I I
1970	Edacode	Teak	46.540	II
1976	Edacode	Teak	50.340	1/11
1978	Edacode	Teak	141.476	1/11
1979	Edacode	Teak	18.750	I
1980	Edacode	Teak	5.542	I
Karulai Range				
1967	Ezhuthukal-Vattikkal	Teak-Mahogany	69.850	I/II
1967	Ingar	Teak-Bombas	22.220	I I
1967	Kallenthode	Teak	27.410	I I
1968	Ezhuthukal	Teak	70.150	1/11
1968	Ingar	Teak-Bombax	20.970	1/11
1968	Kallenthode	Teak	47.190	I I
1969	Ezhuthukal	Teak	48.900	1/11
1969	Ingar	Teak-Bombax	18.500	I
1969	Kallenthode	Teak	61.020	II
1969	Poolakkappara	Teak	55.140	1/11
1970	Nedumgayam	Teak	63.440	I I
1970	Poolakkappara	Teak	44.300	I/II
1971	Cherupuzha	Teak	70.110	1/11
1971	Ezhuthukal	Teak	52.900	1/11
1971	Ingar	Teak-Bombax	20.550	1/11
1971	Poolakkappara	Teak	51.500	II/III
1972	Nedumgayam	Teak	28.295	II
1972	Poolakkappara	Teak	47.912	II
1972	Poovathikadavu-Nedumgaya	Teak	28.295	I
1973	Ezhuthukal	Teak	84.500	1/11
1973	Ingar	Teak-Bombax	34.625	I
1973	Nedumgayam	Teak	65.000	I
1974	Ezhuthukal	Teak	49.250	I
1974	Mundakadavu	Teak	19.366	I/II
1974	Nedumgayam	Teak	24.597	I

Year	and name of plantation	Species	Area (ha.)	Site quality
1775	Ingar	Teak	20.177	I
1975	Mundakadavu	Teak	5.500	II/III
1976	Ezhuthukal	Teak	40.500	I
1976	Ingar	Teak	6.740	1/11
1976	Nedumgayam	Teak	35.812	1
1777	Ezhuthukal	Teak	49.057	I
1977	Ingar	Teak	39.060	I
1977	Nedumgayam	Teak	30.900	1/11
1778	Nedumgayam	Teak	40.550	1/11
1978	Pulimunda	Teak	46.250	I
1979	Ingar	Teak	9.500	I
1977	Ingar	Teak	21.800	I
1779	Sankarancode	Teak	26.300	III
1980	Churulipotty	Teak	19.550	
1980	Kadannakappu	Teak	96.000	I
Nilambur Range				
1975	Aruvallikavu	Teak	22.370	1/11
1976	Kanakutha	Teak	41.050	1/11
1777	Kanakutha	Teak	16.050	1/11
1978	Aruvallikavu	Teak	1.012	I
1778	Erampadam	Teak	34.780	1/11
1978	Kanakutha	Teak	82.050	I
1979	Kanakutha	Teak	108.230	1/11
1980	Erampadam	Teak	11.000	1/11
1980	Walluvassery	Teak	13.436	I
1772	Kariem Mariem	Teak	49.790	1/11
1773	Kariem Mariem	Softwood	56.880	1/11
1973	Kariem Mariem	Teak	58.750	1/11
1774	Kariem Mariem	Teak	51.430	1/11
1776	Kariem Mariem	Teak	58.750	I
1777	Kariem Mariem	Teak	162.506	I

Appendix : 8

Number of teak poles equivalent to $1m^3$ of teak wood

Class of teak poles	Number
	4.2
II	8.5
III	14.1
IV	35.3
V	70.6
VI	142.9

Source : KFRI, 1979

Appendix : 9

Distribution of yield in logs, poles and firewood from teak plantations in Nilambur Divisions

Type of work	Mean age	irth and quality class of teak logs (m^3/ha)												Timber total
		1A	IB	IC	IIA	IIB	IIC	IIIA	IIIB	IIIC	IVA	IVB	IVC	
1M	6	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2M	8	0.000	0.012	0.000	0.000	0.004	0.000	0.000	0.001	0.000	0.000	0.002	0.000	0.018
1S	13	0.000	0.013	0.003	0.000	0.260	0.022	0.000	0.081	0.060	0.000	0.215	0.117	0.772
2S	19	0.000	0.000	0.000	0.000	0.004	0.005	0.000	0.077	0.023	0.001	0.339	0.070	0.518
3S	28	0.000	0.002	0.003	0.000	0.091	0.038	0.000	0.699	1.975	0.000	1.805	3.175	7.787
4S	41	0.000	0.048	0.000	0.000	1.038	0.125	0.000	3.100	0.170	0.000	3.613	0.328	8.423
FF	53	0.000	1.051	0.139	0.010	20.817	1.199	0.010	28.618	2.825	0.000	22.165	6.731	83.565
Total		0.000	1.126	0.145	0.010	22.214	1.389	0.010	32.576	5.053	0.001	28.138	10.42	101.083

Type of work	Girth and quality class of poles (m3/ha)										Pole total	Billet	Fire wood	Total
	IA	IB	IC	IIA	IIB	IIC	III	IV	V	VI				
1M	0.000	0.000	0.000	0.000	0.000	0.000	0.086	1.035	3.148	0.371	4.641	0.000	0.000	4.641
2M	0.000	0.011	0.002	0.000	0.104	0.047	0.766	3.164	1.625	0.257	5.976	0.000	0.000	5.994
1S	0.000	0.051	0.023	0.000	0.031	0.144	0.841	2.666	0.643	0.119	4.518	0.000	0.000	5.291
2S	0.001	0.034	0.086	0.000	0.122	0.837	1.287	1.311	0.461	0.026	4.166	0.000	0.234	4.917
3S	0.009	0.122	0.407	0.005	0.210	1.917	2.655	1.487	0.052	0.000	6.864	0.074	0.947	15.672
4S	0.002	0.211	1.026	0.005	0.273	1.524	2.338	0.522	0.005	0.000	5.904	0.339	0.949	15.615
FF	0.000	0.059	0.020	0.010	0.208	0.327	1.358	0.050	0.000	0.000	2.032	1.011	12.520	99.128
Total	0.012	0.488	1.564	0.020	0.948	4.796	9.331	10.235	5.934	0.773	34.101	1.424	14.650	151.258

Appendix : 10

Percentage distribution of yields in logs, poles and firewood from teak plantations in Nilambur

Type of work	Mean age	Girth and quality class of teak logs (m3/ha)												Timber total
		IA	IB	IC	IIA	IIB	IIC	IIIA	IIIB	IIIC	IVA	IVB	IVC	
1M	5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2M	8	0.00	0.20	0.00	0.00	0.06	0.00	0.00	0.02	0.00	0.00	0.02	0.00	0.30
1S	12	0.00	0.25	0.05	0.00	4.92	0.41	0.00	1.54	1.14	0.00	4.07	2.22	14.60
2S	18	0.00	0.00	0.00	0.00	0.08	0.10	0.00	1.56	0.46	0.02	6.89	1.42	10.53
3S	29	0.00	0.01	0.02	0.00	0.58	0.24	0.00	4.46	12.60	0.00	11.52	20.26	49.69
FT	41	0.00	0.31	0.00	0.00	6.65	0.80	0.00	19.85	1.09	0.00	23.14	2.10	53.94
FF	56	0.00	1.06	0.14	0.01	21.00	1.21	0.01	28.87	2.85	0.00	22.36	6.79	84.30

Type of work	Girth and quality class of poles (m3/ha)										Pole total	Billet	Fire wood	Total
	IA	IB	IC	IIA	IIB	IIC	III	IV	V	VI				
1M	0.00	0.00	0.00	0.00	0.00	0.00	1.86	22.30	67.84	8.00	100.00	0.00	0.00	100.00
2M	0.00	0.19	0.03	0.00	1.74	0.78	12.78	52.78	27.11	4.29	99.70	0.00	0.00	100.00
1S	0.00	0.97	0.44	0.00	0.59	2.72	15.89	50.38	12.16	2.25	85.40	0.00	0.00	100.00
2S	0.02	0.69	1.74	0.00	2.49	17.02	26.18	26.67	9.38	0.53	84.72	0.00	4.75	100.00
3S	0.06	0.78	2.60	0.03	1.34	12.23	16.94	9.49	0.33	0.00	43.80	0.47	6.04	100.00
FT	0.01	1.35	6.57	0.03	1.75	9.76	14.97	3.34	0.03	0.00	37.81	2.17	6.08	100.00
FF	0.00	0.06	0.02	0.01	0.21	0.33	1.37	0.05	0.00	0.00	2.05	1.02	12.63	100.00

Appendix : 11

Cashflow from teak plantations in Nilambur Divisions with low yield

Type of work	Age (Yr.)	Cost (RS.)	Benefit (Rs.)	Net benefit (Rs.)
Planting	0	2899.00	0.00	-2899.00
Maintenance	1	3663.00	0.00	-3663.00
Maintenance	2	3561.00	0.00	-3561.00
Maintenance	3	1753.00	0.00	-1753.00
	4	358.00	0.00	-358.00
Cultural operation	5	1640.00	0.00	-1640.00
1 Mech. thinning	6	1068.11	5060.07	3931.96
	7	358.00	0.00	-358.110
2 Mech. thinning	8	1402.71	16413.42	15010.71
	9	358.00	0.00	-358.00
Tending	10	2628.00	0.00	-2628.00
	11	358.00	0.00	-358.00
	12	358.00	0.00	-358.00
1 Silvi. thinning	13	532.19	4094.01	3561.82
	14	358.00	0.00	-358.00
	15	358.00	0.00	-358.00
	16	358.00	0.00	-358.00
	17	358.00	0.00	-358.00
Weeding	18	1866.00	0.00	-1866.00
2 Silvi. thinning	19	459.46	1429.37	969.92
	20	358.00	0.00	-358.00
	21	358.00	0.00	-358.00
	22	358.00	0.00	-358.00
	23	358.00	0.00	-358.00
	24	358.00	0.00	-358.00
	25	358.00	0.00	-358.00
Weeding	26	1451.00	0.00	-1451.00
	27	358.00	0.00	-358.00
3 Silvi. thinning	28	2263.34	42272.13	40008.79
Loranthus cutting	29	1093.00	0.00	-1093.00
	30	358.00	0.00	-358.00
Climber cutting	31	462.00	0.00	-462.00
	32	358.00	0.00	-358.00
	33	358.00	0.00	-358.00

Type of work	Age (Yr.)	cost (Rs.)	Benefit (Rs.)	Net benefit (Rs.)
	34	358.00	0.00	-358.00
	35	358.00	0.00	-358.00
	36	358.00	0.00	-358.00
	37	358.00	0.00	-358.00
	38	358.00	0.00	-358.00
	39	358.00	0.00	-358.00
	40	358.00	0.00	-358.00
4 Silvi. thinning	41	5098.43	65323.34	60224.91
Loranthus cutting	42	717.00	0.00	-717.00
	43	358.00	0.00	-358.00
	44	358.00	0.00	-358.00
	45	358.00	0.00	-358.00
	46	358.00	0.00	-358.00
	47	358.00	0.00	-358.00
	48	358.00	0.00	-358.00
	49	358.00	0.00	-358.00
	50	358.00	0.00	-358.00
	51	358.00	0.00	-358.00
	52	358.00	0.00	-358.00
Final felling	53	13115.72	723768.42	710652.70
Total		58560.94	858360.76	799799.81

Appendix : 12

Cashflow from teak plantations in Nilambur Divisions with high yield

Type of work	Age (Yr.)	cost (Rs.)	Benefit (Rs.)	Net benefit (Rs.)
Planting	0	2899.00	0.00	-2899.00
Maintenance	1	3663.00	0.00	-3663.00
Maintenance	2	3561.00	0.00	-3561.00
Maintenance	3	1753.00	0.00	-1753.00
	4	358.00	0.00	-358.00
Cultural operation	5	1640.00	0.00	-1640.00
1 Mech. thinning	6	6679.89	45058.00	38378.11
	7	358.00	0.00	-358.00
2 Mech. thinning	8	5419.85	79676.91	74257.06
	9	358.00	0.00	-358.00
Tending	10	2628.00	0.00	-2628.00
	11	358.00	0.00	-358.00
	12	358.00	0.00	-358.00
1 Silvi. thinning	13	3900.36	82903.33	79002.97
	14	358.00	0.00	-358.00
	15	358.00	0.00	-358.00
	16	358.00	0.00	-358.00
	17	358.00	0.00	-358.00
Weeding	18	1866.00	0.00	-1866.00
2 Silvi. thinning	19	7369.85	99745.90	92376.05
	20	358.00	0.00	-358.00
	21	358.00	0.00	-358.00
	22	358.00	0.00	-358.00
	23	358.00	0.00	-358.00
	24	358.00	0.00	-358.00
	25	358.00	0.00	-358.00
Weeding	26	1451.00	0.00	-1451.00
	27	358.00	0.00	-358.00
3 Silvi. thinning	28	15274.85	330914.62	315639.77
Loranthus cutting	29	1093.00	0.00	-1093.00
	30	358.00	0.00	-358.00
Climber cutting	31	462.00	0.00	-462.00
	32	358.00	0.00	-358.00
	33	358.00	0.00	-358.00

Type of work	Age (Yr.)	cost (Rs.)	Benefit (Rs.)	Net benefit (Rs.)
	34	358.00	0.00	-358.00
	35	358.00	0.00	-358.00
	36	358.00	0.00	-358.00
	37	358.00	0.00	-358.00
	38	358.00	0.00	-358.00
	39	358.00	0.00	-358.00
	40	358.00	0.00	-358.00
4 Silvi. thinning	41	28017.41	381047.72	353030.32
Loranthus cutting	42	717.00	0.00	-717.00
	43	358.00	0.00	-358.00
	44	358.00	0.00	-358.00
	45	358.00	0.00	-358.00
	46	358.00	0.00	-358.00
	47	358.00	0.00	-358.00
	48	358.00	0.00	-358.00
	49	358.00	0.00	-358.00
	50	358.00	0.00	-358.00
	51	358.00	0.00	-358.00
	52	358.00	0.00	-358.00
Final felling	53	66327.57	3742658.20	3676330.64
Total		167610.77	4762004.68	4594393.92