TEAK PLANTATIONS IN KERALA
AN ANALYSIS OF PRODUCTIVITY AND PROFITABILITY

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by

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DECLARATION

I hereby declare that the thesis entitled **Teak Plantations in Kerala An Analysis of Productivity and Profitability,** is a bonafide record of work done by me under the guidance and supervision of Professor K.K. George, School of Management Studies, Cochin University of Science and Technology. The thesis has not previously formed the basis for the award of any degree, associateship or any other similar title to me.

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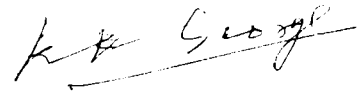
CERTIFICATE

This is to certify that the Ph.D. thesis titled **Teak Plantations in Kerala An Analysis of Productivity and Profitability** is a bonafide record of the research work done by Mr. Mammen Chundamannil (Reg. No.976) under my guidance and supervision and that the thesis has not formed the basis for the award of any degree, diploma or associateship to him.



May, 1997

Prof. K.K. George
Supervising Guide

CONTENTS

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LIST OF TABLES

LIST OF APPENDICES

Chapter 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, durability and workability. It has been described 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 teakwood.

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 1987, teak plantations in India covered 926,484 ha (Karunakaran, 1995).

The growth in area under teak plantations in Kerala is given in Table 1.1. In 1900, the extent of teak plantations was only 546 ha Even up to 1940, teak was the only plantation species in forests. In the 1950s, plantations of teak mixed with bombax were also started. In the sixties and seventies eucalypt plantations also expanded rapidly. During the same period area under teak plantations also expanded considerably. As on 1994, teak occupied an area of 75,000 ha which accounts for 48.3% of the total forest plantations in the state (Kerala Forest Department, 1994).

The age distribution of teak plantations in Kerala is given in Table 1.2. Plantations of age from 10 to 40 years account for 75.4% of the total. Of late, the pace of plantation expansion has slackened and plantations below 10 years account for only 5%. Table 1.3 shows the average annual revenue and investment in Kerala forests. It can be seen that actual investment as a percentage of revenue was only one-fifth or less in the different Five year plan periods. Forests were managed as a surplus generating department for the government.

Table 1.1
Growth in area under teak plantations in Kerala

(Area in ha)

Year	Teak	Teak mixed with other species	Eucalypts	All Plantations
1900	546			551
1910	1685			1701
1920	2879			2945
1930	7859			8088
1940	15258			15847
1950	21820	60	6	23494
1960	33121	5569	275	47400
1970	53486	16924	23533	101774
1980	73927	23174	32817	140283
1990	76502	31899	31609	153012
1994	74947	34526	29066	155071

Source : Chundamannil 1993; Kerala Forest Department 1994.

Table 1.2
Age structure of teak plantations in Kerala as on 1995

Age group (years)	Percentage of area	Cumulative percentage of area
0 - 9	4.9	4.9
10 - 19	23.4	28.3
20 - 29	28.5	56.8
30 - 39	23.5	80.3
40 - 49	8.8	89.1
50 - 59	7.0	96.1
>59	3.9	100.0
	100.0	

Source Compiled from the files of the Kerala Forest Department

Table 1.3
Average annual revenue and investment in Kerala forests
(at constant 1970-71 prices)

Plan	Period	Total revenue (Rs million)	Total expenditure (Rs million)	Investments in forestry		
				(Rs million)	As % of revenue	As % of expenditure
II	1956-61	61	17	9	14	53
III	61-66	78	26	14	18	56
A.P	66-69	84	31	19	21	57
IV	69-74	96	32	17	18	53
V	74-78	138	40	19	14	47
A.P	78-80	196	44	20	20	45
VI	80-85	152	50	21	14	43

Source Chundamannil (1992)

Even the meagre investment was concentrated in short term investments in extracting timber from the natural forests (Table 1.4). Long term investments which contribute to increase the future production of the forests such as plantation raising and fire protection received only a small proportion.

For centuries, teak was harvested from the natural forests in a system of selection felling. Currently the major source of teakwood is plantations. There has been a rapid expansion of forest plantations globally since the early sixties (Evans, 1982). In Kerala also the pace of plantation expansion accelerated around the same time and teak was the prime species (Chandrasekharan 1973). Even before the plantation era, teak from natural

forests was an important source of revenue for the state (Bourdillon 1893). In India teak plantations initiated in Kerala over one and a half centuries ago, continue to be the mainstay of the plantation programme (FRI, 1961; George, 1961).

Table 1.4
Percentage distribution of average annual investments
(at constant 1970-71 prices)

Plan	Period	Short term investments	Long term investments			
		selection felling (%)	Plantations (%)	Regeneration in natural forests (%)	Fire protection (%)	Total (%)
II	1956-61	91.6	8.4	NA	NA	100
III	61-66	76.3	23.3	0.2	NA	100
A.P	66-69	71.8	27.7	0.2	0.3	100
IV	69-74	83.2	14.8	0.1	1.9	100
V	74-78	81.9	15.8	0.4	1.9	100
A.P	78-80	75.9	20.7	1.5	1.9	100
VI	80-85	69.9	27.3	0.8	2.0	100

Source Chundamannil (1992)

Relative to other plantations, teak plantations received the highest level of investment except during the period 1961-1969 when eucalypts received a higher investment. Table 1.5 gives the investment in forest plantations in Kerala for the period 1956-57 to 1989-90. It can be seen that both returns and profitability were higher for teak plantations than that of any other plantations. However, considering the total revenue of the Forest

Department, the revenue from plantations was only around 10% up to 1985. The rest of the revenue was obtained from clearfelling and selection felling in the natural forests. Large scale forest clearance for expansion of agriculture, colonisation programmes, reservoirs, roads etc. also contributed to forest revenue.

Table : 1.5
Average annual investment and revenue from plantations
(at constant 1970-71 prices, Rs. in thousand)

Plan and period	Pure Teak		Teak mixed with Bombax etc.		Eucalypts		Others	
	Invest-ment	Revenue	Invest-ment	Revenue	Invest-ment	Revenue	Invest-ment	Revenue
II (56-61)	470 (10.24)*	4590	130 (433)	30	10 (----)	0	160 (69)	230
III (61-66)	1310 (16.44)	7970	390 (39000)	1	1380 (19714)	7	230 (460)	50
Annual (66-69)	1710 (48.86)	3500	470 (7833)	6	2850 (40714)	7	120 (75)	160
IV (69-74)	1030 (14.05)	7330	310 (182)	170	930 (1550)	60	270 (81)	330
V (74-78)	1060 (15.59)	6800	310 (119)	260	900 (264)	340	700 (170)	410
Annual (78-80)	1800 (15.35)	11730	480 (300)	160	1210 (268)	450	680 (107)	630
VI (80-85)	1950 (17.54)	11120	410 (120)	340	760 (115)	660	2680 (609)	440

* Percentage of investment to revenue

Source : Chundamannil (1992)

Large scale eucalypt plantations, that were raised with high investments in the Five Year Plans were all earmarked for the pulp industry. The pulp wood industry manufacturing paper, newsprint and rayon receives special consideration from the government. Before setting up of such units, the government had entered into a contract to supply a pre-determined quantity of forest raw material at highly subsidised prices. These long term contracts at prices below the replacement cost, deprive the Forest Department from earning sufficient revenue for reinvestment. These plantations were raised to supply the raw material commitments to the pulp industry (Chundamannil, 1990). There have been a big drain on the exchequer and the accumulated losses have been substantial (Krishnankutty and Chundamannil, 1986).

The other plantations such as bombax are just maturing for harvest. Anyway, none of the other plantations can be compared with the revenue earning capacity of teak. Although teak is a long rotation crop, the periodic thinnings starting from the fifth year onwards fetch substantial revenue. Teak continues to be the most profitable among all the plantations raised by the forest department. Due to high prices and reduction in the availability from the natural forests, teakwood is imported from Myanmar to Kerala.

Teak plantations were initiated in Kerala in 1842, and extended almost continuously. Among plantations raised by the Forest Department, teak occupies the largest area and a substantial asset base has been created. Of late, several teak growing private companies have come up offering investors

high returns from their plantations. However, no study has been carried out in Kerala on the economic status of teak plantations in the government forests and prospects of investing in teak plantation ventures in the private sector. The present study is relevant in presenting the productivity status of teak plantations in government forests in Kerala and its commercial profitability. This will be useful to the government for planning management strategies and investment priorities. The study will also serve as a base-line information for comparative studies.

1.2. Objectives

The objectives of this study are

1) to review the forest management in Kerala with special reference to teak plantations,
2) to evaluate the productivity of teak plantations in government forests in Kerala,
3) to analyse the profitability of teak plantations in government forests and
4) to discuss the claims of private sector teak plantation companies in the light of the performance of government teak plantations.

1.3 Plan of the thesis

The thesis is organised in eight chapters including introduction (Chapter 1). Chapter 2 deals with the methodology, definitions and data base used for the study. Chapter 3 reviews the forest management in Kerala and traces the history and development of teak plantations. Chapter 4 examines the level of productivity attained in the government teak plantations in Kerala. Productivity for Nilambur Forest Divisions adopting a rotation of 50 years and for other Divisions following a rotation of 60 or more years is separately analysed. The yields obtained during different thinnings and final felling are also compared with the expected yields in All India Yield Tables.

Chapter 5 analyses the profitability of teak plantations in government forests in Kerala. The profitability is evaluated on the basis of benefit cost ratio, internal rate of return and net present value. The prospects of investing in teak plantation companies in the private sector are examined in Chapter 6. Chapter 7 consists of a discussion on the issues in productivity in government forests. Chapter 8 presents the summary and conclusions of the study.

Chapter 2

LITERATURE REVIEW AND METHODOLOGY

This chapter contains a review of literature on teak plantations and the methodology used for analysing the productivity and profitability of teak plantations. A brief outline of the activities in teak plantation management and the forestry terms relevant for this study is included here.

2.1 Review of literature

Although there is a profusion of literature on teak and several bibliographies on teak are available 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^3/ha 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 II, 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 based 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 II 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 are 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.

The effect of continuous teak plantation on the soil properties and the capacity of the site to sustain the level of productivity was a serious issue discussed amon foresters. Browne (1929) ascribed poor growth in some second rotation teak plantations in Nilambur to soil deterioration under the first rotation plantation. The need to maintain site productivity in the context of teak plantations in Nilambur was stressed in the third Silvicultural Conference in 1929 (FRI and C, 1929). Champion, the central Silviculturist carried out an extensive study of the problem and brought out a forest bulletin on 'the problem of pure teak plantations' (Champion, 1932). He found the soil to be comparatively much harder in plantations apparently due to exposure to the sun and wind in the hot season and to the effect of drip in the rains. The hardening of the surface soil under pure teak without any undergrowth promoted rapid erosion which resulted in excessive washing away of the fertile top soil. The adverse effect of erosion was aggravated in plantations affected by fire. He mentioned that although adequate experimental evidence of soil deterioration under pure teak was lacking it was advisable to maintain a natural undergrowth and to provide strict fire protection to protect the soil against soil deterioration. This view was endorsed by the Fourth Silvicultural Conference in 1934 (FRI & C, 1934) and the Fifth Silvicultural Conference 1939 (FRI & C, 1941).

The Fourth Silvicultural Conference maintained that evidence of soil deterioration in Nilambur teak plantations was lacking while Gupta (1946) was of the opinion that there was site deterioration after clearfelling and planting of teak in Nilambur Divisions. Davis (1940) reported that there was no site deterioration in alluvial soils near the river banks. He, however, mentioned that the teak plantations tend to stagnate after a time or even to be invaded by more shade tolerant species resulting in the replacement of teak. There is a view that growth of teak alternates between faster and slower growth. The reasons for slower growth are damage by insects, overcrowding, over shadowing by faster growing trees and fire (Anon 1897).

Griffith (1937-38) was sceptical of the benefits of a cover crop in teak plantations. Laurie and Griffith (1942) reported that if secondary influences such as erosion, fire and heavy grazing are excluded, proof of soil deterioration under pure teak was lacking although theoretical considerations indicate that it is likely. Temporary adverse conditions may hinder regeneration, but these can be overcome by soil working and other measures.

Davis (1940) believed that conversion of natural forests to teak plantation led to laterization of the soil leading to lowering the moisture retaining capacity of the soil and shortening the effective teak growing season itself. In his opinion degradation of pure teak plantation is either due to the

exposure of the underlying laterite rock or due to the formation of laterite from very complex weathering of the soil itself.

Griffith and Gupta (1947) contested the opinion of Davis after a detailed study of the soils in natural forests and teak plantations. They reported that the chemical composition of the soils were not affected and that only the physical condition was degraded by becoming more hard. They concluded that it is not the actual formation of laterite but the hardening of the already existing laterite soil or laterite rock on exposure and insolation under teak plantation that was responsible for the deterioration of teak quality in Nilambur. They attributed past failures in Nilambur to faulty site selection.

Reports from other parts also highlighted the adverse effects of pure teak plantations on the soil, particularly on plantations on steep slopes and fire prone areas. Ghani (1951) reported that soils under teak plantations, affected by severe erosion and lack of undergrowth, behaved like laterite. Chowdhury (1951) also adhered to the same view and reported that the process of laterization was accelerated by pure teak plantations due to the absence of soil cover.

Kadambi (1945) did not find any soil deterioration in Mysore and ascribed this to the favourable effect of the appearance of natural undergrowth under teak plantations. Blanford(1922) stated that in Burma (now Myanmar) there was no soil deterioration under pure teak except by soil

erosion. Annual erosion losses up to 152 tonnes per ha has been reported from teak plantations in Trinidad while it was only 17 tonnes per ha in the adjoining natural forests (Evans, 1982). Blanford (1933) reported that pure teak led to serious erosion in Burma but no other deterioration in soil could be postulated. He had noticed earlier that teak plantations in Burma grew exceedingly well in the earlier years but the growth deteriorated considerably after about 20 years (Blanford, 1922).

Seth and Yadav (1959) confirmed that the problem was acute where sufficient undergrowth was absent and where fire protection was neglected. The performance of teak deteriorated when the plantations were extended up the slope and in lateritic areas. Jose and Koshy (1972), analysing soil characteristics under teak plantations in Nilambur, found that organic matter content decreased and soil deterioration occurred up to the age of 30 years in newly formed plantations and thereafter it was built up. They also found that considerable compaction of soil had taken place in the second rotation areas.

The problem of site deterioration in plantations cannot be ignored as second and subsequent crops under the management regime involving no active soil amelioration measures will result in a progressive deterioration of physical and chemical conditions of soil (Lundgren 1980). Alexander *et al.* (1980) found that *taungya* cultivation with tapioca in young teak plantations accelerated soil erosion in Kerala.

Occurrence of fire is very frequent in almost all teak plantations in Kerala. The deleterious effects of fire on teak plantation growth and wood quality is well known. It could wipe out a very young plantation (Ansep, 1925). In older plantations it could eliminate the undergrowth, burn up the organic matter in the soil and reduce the number of soil organisms. Blanford (1933) reported that epicormic shoots develop in teak trees following fire.

The importance of maintaining a natural undergrowth with protection from fire and grazing to maintain the productivity of plantations was stressed by Champion (1933). He added that in Europe, the main object of underplanting was maintenance and improvement of the soil. Studies in Indonesia showed that teak is very susceptible to root competition especially of grass and *Imperata cylindrica.* With heavy weed growth, the teak plants stagnate and the leaves become yellow and in severe cases the tops of trees may die off. To prevent the grass growth, alternate rows of green manure crops are raised in Indonesia (Coster, 1939).

Eidemann (1932) of Indonesia reported no benefit of cover crops in teak plantations. Griffith (1937-38), a senior Indian forester, was of the opinion that a cover crop could not benefit teak plantations. However, Alexander *et al.* (1982) recommended that intercrops which provide cover namely *Leucaena leucocephala, Calliandra calothyrsus* and *Acacia auriculiformis* may be tried to mitigate deliterious effect of soil erosion.

Pest problems are reported to be serious in Nilambur. Defoliating insect attack in plantations can seriously reduce the annual volume of increment (Nair *et al.* 1985) Beeson (1931) studied the impact of defoliating pests in Nilambur teak plantations and found that severe defoliation occurred in the pre-monsoon period (April-June). Champion (1935) justified expenditure to prevent severe defoliation as considerable loss of increment was reported. Hole (1901) mentioned that defoliating insects did mild damage to teak in Rangoon division and added that there was nothing extra-ordinary or serious about it. The large scale expansion of teak plantation in Nilambur without maintaining a buffer of natural forest around each plantation and failing to maintain adequate undergrowth could be the reason for the severity of the defoliation problem in Nilambur. Innovative research efforts to control the defoliating pests using biological control measures are ongoing in KFRI.

Water blister is another problem reported from teak plantations along water courses. Bakshi and Boyce (1959) advised to avoid planting teak in very moist sites where water blister usually develops. Kallarakkal *et al* (1992) reported that the prevalence of the problem of water blister in teak trees is limited to within 50m of river banks or water sources. As one moves away, the frequency of affected trees gets reduced and beyond 350m the problem is absent. Water blister is not fatal to the trees but the quality of timber is affected.

The manual of Indian silviculture places the greatest importance to timely silvicultural operations in plantations (Champion and Trevor, 1938). The authors stated that many plantations failed although the work was excellently done, simply because some operations were done after the optimum time for them. They added that a late start is peculiarly fatal as casualties and weed troubles are greatly increased even to the extent of making the plantations more or less a failure. Carrying out of thinning operations at the right time and in the right intensity is very important and the economic return from the plantation will be greatly affected if these are ignored (Sagreiya, 1947).

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.

Kjaer and Foster (1996) have done a study of the economics of tree improvement of teak based on a projected gain in Mean Annual Increment (MAI) from using genetically superior seedlings. A high present value is estimated for tree improvement programmes even if teak prices remain unchanged. This is so notwithstanding the fact that research and development costs for screening and mass producing genetically superior planting materials are quite high.

In another report on teak research and development, White (1991) mentioned that international provenance trials with teak seeds of different origins showed that the best all round performance with respect to health, growth and quality on a variety of sites was recorded by seeds of Konni (Kerala) origin and Bangsri (Indonesia). He adds that the Bangsri provenance is possibly a distributive descendent of the Indian provenance. Trials in Australia also showed that teak provenance of Kerala origin showed the highest diameter and basal area growth among a range of international sources.

On the problem of pure teak plantation, White (1991) comments that the old problems are still current. Among them soil deterioration, soil erosion, volume decline in later generations, defoliation etc. are still debated.

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.

2.2 Methodology

There are different operations in the management of a teak plantation. The operations are 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 thinnings - 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 are 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 indicates 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 is 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.

2.2.1. Productivity analysis

For the productivity analysis, the parameters used are mean yield, MAI and expected yield 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 separately for Nilambur Divisions and together for the 14 other divisions. The results are presented separately for Nilambur Divisions, Other Divisions and Kerala. 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(1981). 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 corresponding 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 same analysis was done for the rest of Kerala.

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.

2.2.2 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 (1M, 2M), first to fourth silvicultural thinnings (1S,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 3rd 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 eventually 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 is needed. 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 = Net present value (Rs.)

B_t = Benefit (Rs.) in the year t

C_t = Cost (Rs.) in the year t

n = Rotation age in years

i = Discount rate

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 exists. 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.1300ha^{-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 IRR, 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.

2.2.3 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, documents and publications such as Working Plans and Annual Administration Reports 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 files. The Divisional Forest Offices also have files 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.

The yield data for teak plantations in Other Divisions was collected from 14 Forest Divisions viz. Thenmala, Konni, Ranni, Punalur, Kottayam, Munnar, Kothamangalam, Chalakkudy, Vazhachal, Thrissur, Parambikulam, Wynad South, Wynad Wild Life and Wynad North. The number of operations in different thinning and final felling was 363 with an area of 17,131 ha. (see Appendix 2 for division wise distribution and Appendix 1 for yield data.)

Teak timber from plantations are 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 4. Logs of the same size and quality classes are grouped into lots of not more than 5 m^3 These lots are sold in monthly open competitive auction. Each depot has separate files for each monthly auction. Price data for different girth and quality classes for the year 1995 were collected from Chaliyam, Nedumkayam 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.

Chapter 3

HISTORICAL REVIEW OF FOREST MANAGEMENT

This chapter reviews the forest policy and management in Kerala to provide a perspective on the development of teak plantations.

3.1 Forest management in the pre-independence period

Traditionally, forest management in Kerala was limited to the extraction of a few species of large size timber mainly for export. The operation was a selection felling of teak, rosewood, ebony, sandal and a few other species. As accessibility was limited, the tree growth adjoining navigable rivers were depleted quite rapidly.

Prior to independence, Kerala was made up of three political entities of which Travancore and Cochin were independent states owing allegiance to the British East India Co. and later British Crown. The Malabar region was directly ruled by the British. The forest policies followed in all the three regions were more or less similar except for the fact that extensive private forests existed in Malabar. Before the advent of the European trading companies in Kerala there was a flourishing trade with Arabs who possessed a powerful naval fleet, in the construction of which teak from Malabar was used (Mobbs, 1941).

In Travancore, a timber depot was opened at Alleppey during the end of the eighteenth century. Large supplies of teak for naval construction from Idiyara valley (Malayattur) was also reported (Iyppu, 1962). Ward and Conner (1863), who surveyed Travancore and Cochin during 1817-20 reported that lease of river basins to contractors for the extraction of teak was being replaced by direct working by government agency.

It was the revenue compulsion that dominated the intensification of exploitation of forests in Travancore and Cochin. In Malabar, which was under the direct rule of the British, it was the strategic interest of obtaining sufficient supplies of teak timber for the British naval and merchant fleet that attracted the administrators. As early as 1796, a European timber syndicate in Malabar was engaged in the extraction and export of teak.

Prior to teak planting activities, the efforts of the forest department were focused on facilitating the extraction of old growth of teak from natural forests. The timber-slip at Anamalais (Cleghorn, 1861), the tramway from Chalakudy to Parambikulam (Viswanathan, 1958) and rock blasting operation in the rivers of Travancore to facilitate floating of logs were some of the important investments in the forest sector (Bourdillon, 1893).

The shift to steel in Naval ship building following the sinking of two wooden ships during the American Civil War in 1862 reduced the importance

of teak as a crucial Naval priority (James 1981). But even before the importance of teak for ship building receded railway construction requiring teak timber had started in India. Railways were started as a commercial enterprise but following the rebellion against the company in 1857 by many princely states, railways became an urgent internal security priority (Guha and Gadgil 1988). By 1862, nearly one million railway sleepers were required annually.

Although defence, railway, and conservation interests were paramount in the initial stages when the forestry administration was set up, forestry was organised on commercial lines with sustained yield as an important principle of management. By the time the first Inspector General was posted and the Forest Act passed, teak was no longer a defence priority for shipbuilding, but railway supplies were. The advantage with railway supplies was that it was easy to foresee the demand in the coming years and production planning could be made accordingly.

Railways had high state priority as it was built to facilitate troop movements and trade (Guha and Gadgil, 1988). In 1862 Lord Delhousie called for the establishment of a Department that could ensure the sustained availability of the enormous requirements of the different railways for sleepers (Guha 1983). Nearly one million sleepers were required annually and Delhousie observed that impending shortages made the subject of forest conservancy an important administrative question (Guha and Gadgil 1988).

Railways required not only timber but also huge quantities of fuel for its steam engines. As large forest tracts were denuded within no time for railway supplies, future supplies for the existing network and the planned expansion became a cause for worry.

In 1864, the first Inspector General of Forests in India, Dr. Dietrich Brandis was appointed. As forestry was undeveloped in Britain, German professionals were posted to organise forestry on a scientific basis in India. The successors of Dr. Brandis, Berthold Ribbonthrop and William Schilich, were also from Germany. The early foresters in India with German training and their successors brought in professionalism to the practice of forestry and sustained yield management came to be adopted as the cardinal principle of forestry. German forestry science and yield regulation methods came to be an integral part of forestry planning and management in India. A carefully prepared working plan containing detailed prescriptions for the management of a reserve or division was the main tool of management.

The value and properties of teak timber were known from very early times. Indian and Arab ships were constructed with teak from Malabar (Kunhikrishnan, 1987). The East India Company of England which finally displaced the Arabs also learnt the value of teak timber for shipbuilding. Large supplies of teak were sent to the Bombay dock for merchant and naval shipbuilding. However as large sized teak became scare, the court of Directors of the East India Company enquired in 1805 about the possibility

of a sustained supply of teak timber for the British Navy to retain its control over the shipping routes. A conservator was appointed in 1806 to regulate teak trade and to ensure steady supplies to the company. The Collector of Malabar, Mr. H.V. Conolly, meanwhile suggested that private forests could be leased in and operated to ensure a steady supply of teak timber for the company. As the area required as estimated by Conolly was very extensive, the Court of Directors suggested that plantations should be tried. Overcoming several initial problems, the first teak plantation was raised in Nilambur in 1842 (Ribbonthrop 1900; Stebbings 1922).

The credit of initiating systematic planting of teak in India goes to H.V. Conolly, Collector of Malabar. Raising of teak as a forestry enterprise marks a momentous shift from a purely extraction and regulatory function of forestry to a phase of resource development. The breakthrough in germination of teak seeds is credited to Mr. Bates, Head Accountant in the Collector's office. H. Smith and Sergeant Graham appointed successively by Conolly between 1841 and 1843 to plant teak, initiated several experiments on their own besides those suggested by Dr. Wight, Superintendent of the Cotton Farms and Monsieur Perottet, Superintendent of the Botanical Gardens in Pondicherry (Bourne, 1921). Chathu Menon, who succeeded them as Sub Conservator achieved success in nursery raising. Chathu Menon served for 18 years from 1844-1862 and was in charge of the plantations throughout the period. The success of the plantations and the bright commercial prospects ensured its continuous expansion.

After a short period of difficulties, the teak plantations did surprisingly well and expansion continued regularly. The small beginnings at Nilambur later grew to a vast network of teak plantations in India. Teak plantations were initiated in Travancore in 1865-66 and in Cochin in 1872 (Iyppu, 1962). In Palghat, teak planting operations commenced in 1872 but most of these proved a failure. In Wynad, teak plantations were started in 1876 by Logan, the District Collector.

In Travancore teak plantations commenced at Malayattur in 1865. The appointment in 1867 of Mr. Thomas, trained in the Nilambur Teak plantations, as Assistant Conservator at Konni, assured the success of the venture.

T.F. Bourdillon, coffee planter turned forester (Burkill, 1965) occupies a place of honour in Travancore like that of Conolly in the history of teak plantations in Malabar. Bourdillon who was the Conservator of Forests from 1861 to 1906 in Travancore created 6793 ha. of teak plantations (George, 1961).

Innovations in Travancore made teak plantations even more attractive. They included the adoption of stump planting in Konni in 1878 (Moni, 1959), the method of planting in crowbar holes in 1879 and the adoption of *taungya* method since 1922 for planting and initial care of plantations (Jacob, 1933).

These three innovations greatly reduced the cost of raising plantations and lightened the workload of the Department. Planting, protecting and initial care of the plantation were made the responsibility of the taungya cultivator. The success of taungya enabled plantations to be raised at no cost to the department and often at a premium. From 1908, the tree growth at the site of the plantation was sold to the taungya lessee enabling him to make up any perceived loss in the taungya operations. In 1945, a new clause was added to the taungya agreements by which the taungyadar was called upon to raise the teak nursery also. Later, when large scale plantations were raised, nursery and planting work was done using hired labourers under the supervision of forest officials. In Malabar, taungya method was introduced in 1926-27 and stump planting started only in 1936 (Nair, 1960).

Plantation expansion was interrupted in Nilambur between 1877 and 1885 and between 1913 and 1916 following field inspections by the Conservator of Madras. In the first instance expansion was stopped as the older plantations were not receiving sufficient care. In the second instance, poor results in the plantations of preceding years was cited as the reason. Mac Iver, the Superintendent of the Botanical Gardens at Ootacamund, supervised the first thinning in 1852. Subsequently Chathu Menon attended to the thinning and pruning of the plantations himself. The Conservators of Madras, starting with Hugh Cleghorn showed keen interest in the Nilambur plantations and gave useful suggestions during their inspections. In 1898, Ribbenthrop, Inspector General of Forests visited the Nilambur plantations.

He recommended the annual extension of plantations on suitable area, as much as possible, subject to the limitation posed by the availability of labour (George, 1961).

The Forest Acts of 1865 and 1878 laid down the procedure for creating and administering forest reserves. Sustained supply of forest products for the local population was not the primary objective of these Acts. The need for ship building timber, railway sleepers and construction timber for public works projects was the over riding objective (Taylor, 1981). Forest reservation was adopted as a policy only when the potential wealth and revenue generating capacity of the forests were recognised (Shiva, 1986).

Similar Acts were passed in Travancore and Cochin also. A National Forest Policy was declared in 1894 in British India. This policy affirmed that forestry was a handmaid of agriculture and whenever forests were required for agricultural expansion forests were to be relinquished. Four different classes of forests were identified: 1) Protection forests for climatic and ecological needs. 2) Valuable forests for commercial timber and revenue. 3) Minor forests and 4) Pasture lands for meeting local needs (Troup, 1917).

The early British foresters were mostly surgeons with the army and police, who had fair commitment to conservation. The entry of trained German foresters like Dietrich Brandis, Ribbonthrop and Schilich brought in

German traditions of sustained yield management of forests which came to be known as scientific forestry.

The early foresters with German training and their successors brought in professionalism to the practice of forestry and they were in a position to convince their political superiors about the need to adhere to the scientifically determined quantum of allowable cut from a given area. Scientific forest management which can be described as planning and execution of forestry activities with the objective of sustained yields was initiated by these German officers in India.

The earliest Forest Working Plan in India was prepared by U.V Munro, Conservator of Forests in Travancore in 1837 Stebbings, 1922). Brandis prepared the first Working Plan in the modern format. German forestry science and yield regulation methods came to be an integral part of forestry planning and management in India.

In Malabar, P.M. Lushington prepared the first Working Plan for Nilambur for the period 1896-1905. In British India, there was a lull in the preparation of the Working Plans during World War I, but after the War those who left the department on War Service returned and also there was a fresh and heavy recruitment to the Indian Forest Service leading to the preparation of intensive Working Plans. But the German tradition of forest management based on meticulous Working Plans and rigorous

implementation of its prescriptions did not percolate to Cochin and Travancore.

The sustained yield concept developed in the west found a place in the colonial forest policy in India. However, the initial interest in forest sustention in British India was limited to safeguarding the existence of the more valuable teak forests on which the supply of ship building timber for the navy depended.

In the initial years of forestry in India, the professional judgement of foresters were held in such high esteem that prescriptions of the Working Plans were inviolable. The Second World War however caused a set back to the progress of Working Plans. The normal work of posting entries in compartment histories and submission of forms got into arrears. The worst thing was the carrying out of felling in total disregard to the Working Plan prescriptions (FRI, 1961). None bothered to maintain proper records which used to be the guideline for the preparation of Working Plans for future scientific working.

The major break or disruption in the tradition of forestry was the two World Wars. Many forest officers left for war duty and due to the excessive demand for timber the working plan prescriptions were ignored. As vast areas of unexploited forests existed, it was not difficult to meet the war requirements from the vast reserves and private forests. Developments in the

market, such as the acceptability of species which were not acceptable earlier, technological developments in wood preservation and processing and in communications helped to expand forestry operations.

The World Wars disrupted the import of plywood which was mainly used for tea packaging. Several small plywood manufacturing units came up in Kerala in response to the demand. A government owned Travancore Plywood Industries was also started in 1943 with the technical support of the Forest Research Institute, Dehra Dun.

3.2 Forest management in the post independence period

Forest plantations were opened on a small scale in the pre-independence period; the pace of planting accelerated with the implementation of the Five Year Plans (Chandrasekharan, 1973; FAO, 1984). The expansion of teak plantations in Kerala in the post independence period has an additional cause; it was an acceptable scheme for plan funding. Also Champion had declared that even relatively poor quality teak is preferable to any other possible alternative on economic grounds (Champion, 1932).

The Forest Policy of 1952 focused on the economic aspects of forestry. Departing from the 1894 policy, agricultural expansion at the expense of forests was discouraged. It was stated that forestry was entitled to an adequate share of the land. The commitment to forest sustention was

clearly stated in the 1952 policy. The need for sustained supply of timber and other forest produce required for defence, communications and industry and the need for ensuring progressively increasing supply of grazing, small timber and firewood was emphasised along with the need for evolving a system of balanced and complementary land use where each type of land is allotted to that form of use under which it would produce most and deteriorate least. The need for checking denudation in the watersheds, progress of erosion and desert invasion; the need for afforestation for amelioration of the physical and climatic conditions and for promoting the general well-being of the people and finally the realisation of the maximum annual revenue in perpetuity consistent with the other objectives were stressed in the 1952 Policy. Subsequently these features of the forest policy were incorporated in the Working Plans of the State Forest Departments as objectives of forest management.

Whereas in the 1894 policy, forestry was seen as a hand maid of agriculture and forest lands suitable for agriculture was to be released to agricultural use, the 1952 policy disallowed the practice and even providing for needs of the local agricultural population which was a priority earlier, was replaced with that of supply of forest raw material for industries. Sustained supply of timber and other forest produce required for industries was included in the highest priority category with that of defence and communications. The 1952 policy emphasised a close linkage between forestry and wood based industry.

The period after the war was marked by a sincere effort in afforesting the areas ravaged by excessive felling during the war years. Teak was the most important species used for the work as it was both a valuable and reliable species for raising plantations.

At the international level forestry came to be identified so much with industries that multinational organisations propagated the slogan of forestry for industrial development (Westoby, 1963). It was the recommendation of von Monroy, an FAO expert, that initiated the scheme for large scale plantations of fast growing species for the pulp industry (Von Monroy, 1961).

Forest based industries were encouraged even earlier in Travancore. The first law enacted in Travancore to facilitate the setting up of Joint Stock Companies in 1887-'88 was to facilitate the setting up of Punalur Paper Mill, to produce paper using reeds (Namboodiripapd, 1968). The investment policies followed in the Five Year Plans also favoured expansion of plantations particularly pulpwood and matchwood plantations. Eucalypts raised even in the fuel wood scheme was allotted as pulpwood as the commitments could not be met from the industrial plantations alone (Krishankutty and Chundamannil, 1986). Bombax plantations raised for the small scale match industry during the first few plans are also being diverted to the pulp industry to satisfy commitments to the pulp industry made earlier (Chundamannil, 1993).

The government adopted a policy of supplying forest raw material to wood based industries either on the basis of a contract or as a quota which the large units directly extracted from the forests and the smaller units collected from the government depot. Highly concessional rates were charged for the wood supplied to industries.

The subsidised supply of forest based raw materials encouraged the setting up of a large number of units and expansion in the size of the existing ones. By late 1970s there wasn't enough raw material to satisfy all the units and a formal procedure of rationing the available produce to all the eligible units were initiated.

Match making units also received a quota of timber from the selection felling coupes. For long term supply of timber to match units bombax plantations, often mixed with teak have been raised. They are just getting mature to be felled.

The growth of industries and government commitments to supply a predetermined quantity of raw material from the forests did as much damage as the war. In the competition among states to attract industries often unrealistic commitments were made. These commitments are formal, legally enforceable contracts for the industries, that, like war supplies they have to be met irrespective of whether they represent the sustainable yield. Price

subsidies in the form of a negotiated pre-fixed price or exclusive quotas are a distinctive feature of the commitments (Chundamannil, 1990).

The commitment to sustained yield forestry diminished due to several reasons. Firstly, the prolonged period of the Second World War when the Working Plans were abandoned caused a break with the German tradition. Secondly, the exit of a large number of Indian Forest Service officers during and after the wars eroded the leadership ranks in the profession. Thirdly, the political leadership that emerged in the provinces was faced with immediate and pressing problems such as food shortages, that long term problems of forestry or environment were among the least appreciated.

The Indian Government embarked on an ambitious programme of planned development of the economy laying great stress on an industrialisation strategy. Although the first plan supported small scale industries from the 2nd plan onwards large scale industries were promoted. The expansion of plywood and paper manufacturing directly influenced forest planting and land use. The paper industry was given particularly favourable status as newspaper, literacy, education and packaging needs of a developing society were to be catered to.

In spite of a massive centrally assisted scheme for pulpwood plantations the expansion of teak plantations continued steadily and rapidly. The state forest department preferred teak to all other species because of the

ease with which it could be grown and the experience gained over a century. The high five year plan targets for plantations were many times more than what the divisional working plans recommended. As funding was linked to 5 year plan targets, the plantation programmes also kept pace with the 5 year plan targets rather than the modest working plans. But even this couldn't accommodate all the targeted area and so special teak plantation divisions were formed in Parambikulam, Kallar Valley and Edamala Valley.

The growth of the plywood industry is linked to the policy of boosting the export of tea which became a major foreign exchange earner during the First World War.

In the post independence period with the expansion of clearfelling and selection felling operations and large scale forest clearance for irrigation and hydroelectric projects, wood availability increased and a very large number of sawmills and dozens of plywood manufacturing units came up.

After the formation of Kerala the plywood units secured a quota of timber allotment from the reserve forests. Rapid expansion of plywood capacity on the one hand and the slowing down of large scale forest clearance on the other led to a situation by mid-1970s of wood raw material scarcity.

In Malabar 3106km^2 of private forests existed in 1945 owned by 116 Jenmis and Devaswoms (Viswanathan, 1992). During and after World War II,

extensive forest clearance took place for wood production and for agricultural colonisation. The Madras Preservation of Private Forest Act (MPPF) was enacted in 1949. This act was conservation oriented and aimed at controlling forest destruction. Due to the non-existence or inadequacy of an implementing machinery and the un-surveyed nature of the private forest holding, the deforestation continued.

In 1962, a bill was passed by the Kerala Assembly to nationalise the private forests after compensating the owners. As the bill did not get the president's assent, it lapsed (Karunakaran, 1985). The owners of the private forests intensified their efforts to sell off the trees or the forests at the best possible price prior to the impending government take over.

In 1971 the Kerala Government by an Ordinance, the Kerala Private Forests (vesting and assignment) Act took over the private forests of Malabar. Similar legislation, the Kannan Devan Hills (Resumption of Lands) Act 1971 took over the private forests around Munnar. As both these legislations were under the Kerala Land Reform Act 1963 no compensation was paid to the original owners.

While the objectives of the MPPF Act was to facilitate conservation of forests, the Kerala Private Forest Act 1971 was intended to facilitate conversion of forests to agriculture as a land reform measure. Earlier attempts at land reforms did not generate sufficient lands for redistribution

(Manoharan 1989) to meet the demand from agricultural labourers who were promised land by political parties.

However due to long drawn out litigation and ineffectiveness of the government machinery to co-ordinate the revenue and forest departments, only a small fraction of the private forests came into government hands.

The Report of the National Commission on Agriculture (Government of India, 1976) saw the climax of the phase of industrial orientation of forestry. The Commission was of the opinion that "production of industrial wood would have to be the *raison d etre* for the existence of forests" (Ibid p32-33). The Commission, while recommending an aggressive man-made forestry programme, advised that future production programmes should concentrate on clearfelling of inaccessible hardwood forests, followed by that of mixed quality forests and valuable forests and planting with suitable fast growing species yielding higher returns per unit area. The resulting produce from clearfelled areas should be utilised in wood based industries as far as possible. The Commission recommended formation of state owned Forest Development Corporation in each state to accelerate the industrial plantation. (Government of India 1976). The Kerala Forest Development Corporation was started in 1975 originally to raise eucalypt plantations for the public sector Hindusthan Newsprint Ltd.

Forests was a State subject under the Constitution of India. By an amendment of the Constitution in 1976 forests were placed in the Concurrent List enabling the Centre to make legislation on the subject. The Forest Conservation Act 1980 enacted by the Centre assumed wide powers to regulate forest land use decisions. Under this act the States have effectively lost all powers to sanction non forestry uses of forest land.

The Forest Conservation Act 1980 radically changed the situation. Forest clearance for non-forestry purposes was restricted by the Act and prior permission of the central government was required for even government programmes such as construction of irrigation or power projects within forest areas. By 1982 even clearfelling for creation of new plantations was also stopped.

The Forest Conservation Act effectively checked the previous pace of rapid deforestation for various public and private purposes.

The new national forest policy of 1988 revised the 1952 forest policy by radically changing the direction and priorities in the forest sector. A clear and definite shift towards conservation is indicated in the new policy. The earlier bias towards industries was changed and industries were asked to grow their own raw material rather than depend on forests for the production or expansion. The importance of agriculture was also pegged down. It states that "the principal aim of forest policy must be to ensure environment stability

and maintenance of ecological balance including atmospheric equilibrium which are vital for sustenance of all forms of life.

Selection felling, which was the traditional system of wood production and source of revenue for the department, was opposed by several environmental groups in Kerala. The unsustainability of wood production by selection felling was shown by the Kerala Forest Research Institute (Balasubramanyan 1987). FAO (1984) had already reported various weaknesses and defects in the actual operation of selection felling in the natural forest. The onward movement of selection felling to new areas after depleting the more accessible areas was also pointed out in the study. Political changes contributed to hastening the stopping of selection felling in the forest. The forest minister who took charge in 1986 ordered that not a single tree should be cut from the forest. This order was later amended to the effect that no new selection felling contract will be awarded.

The campaigns by environmental groups in the wake of droughts and for the preservation of Silent Valley forests resulted in a review of forest management policies followed in Kerala. Clearfelling of natural forests even for raising new plantations were stopped in 1984. Selection felling of forests on which the major part of the revenue of the forest department depended was also abandoned in 1987.

In 1986, a high level expert committee on forest policy was appointed by the government of Kerala to review the forest management in the state. Eminent foresters of national standing were included in the committee. The high level committee which submitted its report in 1988 also supported the stopping of selection felling.

The new National Forest Policy of 1988 was conservation oriented and it corrected the bias towards industries in the 1952 policy. With this, plantations became the only source of revenue to the department.

With the stopping of clearfelling and selection felling, the revenue from natural forests began to decline. With this, teak plantations became the only source of sustainable revenue to the department. The other plantations raised such as bombax are just maturing for harvest. Anyway none of the other plantations can compare with the revenue earning capacity of teak. Although teak is a long rotation crop the periodic thinnings starting from the fifth year onwards fetch substantial revenue. Teak continues to be the most profitable among all the plantations raised by the forest department.

Chapter 4

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 (1M), 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 chapter, productivity of teak plantations in the government forests of Kerala based on actual yields is analysed. Comparison of productivity between Nilambur Divisions and Other Divisions is also made here.

4.1 Productivity in Nilambur Divisions

4.1.1 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 4.3 is not the sum of that in Table 4.1 and 4.2, 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 5 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 4.1
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 (m^3/ha/yr)				2.954		1.243	6.128

* CV Coefficient of variation

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

Table 4.2
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 4.3
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 4.1 to 4.3, 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 4.4 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 4.4
Mean, low and high yields from teak plantations in Nilambur Divisions during the period 1967 to 1994

Type of Work	Yield (m^3/ha)		
	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

4.1.2. 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 relative productive capacity 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 (see glossary for the definition of top height).

All India yield tables of teak show seven site 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 6. 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 7. 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 4.5. In the first mechanical thinning (1M), the expected yield in site quality I at the age of 6 years is $19m^3\ ha^{-1}$, whereas in site quality IV it is only $1m^3ha^{-1}$ Similarly in site quality I, the expected yield at final felling at the age of 53 years is $233\ m^3ha^{-1}$ and that in site quality IV is $57m^3ha^{-1}$.

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 4.6. For site quality I plantation, the expected total yield is 435 m^3 and MAI at 53 years is 8.210m^3 ha^{-1} $year^{-1}$ For site quality IV plantation, the expected total yield at the same age is 95 m^3 and MAI is 1.780m^3 ha^{-1} $year^{-1}$

Table 4.5
Yield expected in thinnings and final felling in different site quality classes

Type of work	age	Yield in different site quality classes (m^3/ha)						
		I	I/II	II	II/III	III	III/IV	IV
1M	6	18.66	17.67	16.09	13.98	11.58	1.81	1.23
2M	8	20.89	19.66	17.84	15.04	11.93	5.44	3.69
1S	13	24.51	22.70	19.60	16.44	12.46	8.89	5.97
2S	19	30.10	25.74	20.77	15.97	11.88	8.31	5.38
3S	28	26.37	22.41	17.71	12.75	10.41	7.25	4.33
4S	41	15.85	14.16	12.23	10.06	7.78	5.44	2.87
FF	53	232.50	188.72	152.92	120.92	95.06	75.47	57.45

Source Interpolated from FRI and C (1970)

Table 4.6
Total yield and MAI for specific ages for different site quality classes

Age	Item	Yield in different site quality classes (m^3/ha)						
		I	I/II	II	II/III	III	III/IV	IV
20	Total yield	188.079	177.549	153.271	126.330	100.036	65.228	46.508
	MAI	9.40	8.88	7.66	6.32	5.01	3.26	2.33
50	Total yield	417.987	357.730	295.137	234.296	184.276	131.042	90.091
	MAI	8.36	7.15	5.90	4.69	3.68	2.62	1.80
51	Total yield	423.603	362.878	299.583	237.982	186.909	132.680	91.578
	MAI	8.31	7.11	5.87	4.85	3.66	2.60	1.79
53	Total yield	434.836	373.174	308.476	245.353	192.175	135.956	94.553
	MAI	8.21	7.04	5.82	5.18	3.63	2.57	1.78
55	Total yield	446.068	383.470	317.368	252.724	197.441	139.232	97.527
	MAI	8.11	6.97	5.77	5.50	3.59	2.53	1.76
56	Total yield	450.865	388.092	321.697	256.585	200.366	141.281	98.556
	MAI	8.05	6.93	5.75	5.31	3.58	2.52	1.75
58	Total yield	460.450	397.336	330.355	264.307	206.216	145.379	100.614
	MAI	7.93	6.85	5.71	4.73	3.56	2.50	1.73
60	Total yield	470.054	406.578	339.013	272.030	212.066	149.478	102.670
	MAI	7.83	6.78	5.65	4.53	3.53	2.49	1.71
65	Total yield	491.932	427.054	357.734	290.458	228.447	159.708	110.276
	MAI	7.57	6.57	5.50	4.47	3.51	2.46	1.70

Source Interpolated from FRI and C (1970)

4.1.3. Comparison of site quality and actual yields

Information on site quality is available only for plantations planted prior to 1967. Table 4.7 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 a KFRI research project, the site quality for 45 teak plantations has been determined (Chundamannil, 1997). Appendix 3 gives the list of those plantations and their site qualities.

Table 4.8 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 Chundamannil (1997). Based on that information, percentage distribution of area in different site qualities is presented in Table 4.9. 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 4.7
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	2698.994	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 (1981), Vasudevan (1971) and 2. Chundamannil (1997)

Table 4.8
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 Chundamannil (1997)

Table : 4.9

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 Chundamannil (1997)

Table 4.10 relates to the same set of plantations as in Table 4.9 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 'failure'

Table : 4.10

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)	9 (7)	87 (87)	0 (0)	4 (7)	100
2M	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	70 (75)	10 (9)	20 (16)	100
1S	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (3)	56 (53)	43 (45)	100
2S	0 (0)	0 (0)	0 (0)	0 (0)	2 (7)	29 (43)	10 (9)	60 (41)	100
3S	4 (2)	16 (19)	38 (37)	3 (2)	3 (2)	8 (10)	19 (19)	10 (10)	100
4S	62 (76)	1 (1)	5 (4)	8 (7)	5 (4)	13 (4)	4 (2)	2 (2)	100
FF	0 (0)	10 (5)	0 (0)	10 (16)	7 (11)	22 (26)	24 (11)	27 (32)	100

* Figures in parenthesis denote distribution based on number of plantations

Computed from Ranganathan (1981) Vasudevan (1971) and Chundamannil (1997)

Table 4.11 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 III/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 : 4.11

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		Lowest decile		Highest decile	
				Yield (m^3/ha)	S.Q.	Yield (m^3/ha)	S.Q.	Yield (m^3/ha)	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	III/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
4S	86	1829.303	41	15.615	I/II	4.461	IV	26.029	I
FF	47	1316.844	53	99.128	III	39.543	Failure	204.475	I/II
Total	372	12536.157		151.258	III/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 4.9 and 4.10). 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 4.12. Site quality 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 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 I/II. But the fourth silvicultural thinning at the age of 40 shows an yield equivalent to that of site quality I. This is 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 III/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. Chapter 7 discusses this issue further.

Table 4.12
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	I/II											40	I	56	Failure
1934	Mulathamanna	II/III											40	I	52	III/IV
1934	Nellikutha	II											40	I/II	54	III/IV
1938	Valluvasseri	II									29	I/II	41	II/III	52	III/IV
1939	Valluvasseri	III									30	I/II			52	Failure
1940	Valluvasseri	I/II									28	II			51	III/IV
1942	Valluvasseri	II									28	II	40	IV		
1949	Old Amarampalam	III							18	III/IV	29	III/IV				
1949	Panangode	II							18	III/IV	29	Failure				
1951	Panangode	II							18	III/IV	28	IV				
1952	Valluvasseri	II/III							18	III/IV			37	Failure		
1953	Valluvasseri	II							18	III/IV			37	Failure		
1957	Edacode	II			11	IV	12	IV	18	III/IV						
1959	Edacode	II					12	IV	19	Failure						
1960	Edacode	II			8	III/IV	12	IV	19	Failure						
1960	Ramallur	II			8	III/IV			19	Failure	27	IV				
1961	Sankarancode	II			8	III/IV	12	IV			31	I				
1962	Mundakadavu	II			8	III/IV	13	IV			28	Failure				
1963	Mundakadavu	II			8	III/IV	12	IV			26	Failure				
1964	Edacode	II	4	III/IV	8	III/IV	13	Failure								
1965	Edacode	II			8	III/IV	13	Failure								
1965	Ezhuthukal	II			10	IV	13	Failure								
1970	Poolakkappara	I/II	5	III/IV	8	III/IV	12	Failure	22	Failure						
1971	Ezhuthukal	I/II	4	III/IV	8	III/IV			21	Failure						
1972	Poolakkappara	II	4	III	8	III/IV	12	Failure	20	IV						
1974	Nedumgayam	I	4	III/IV	8	Failure	12	Failure	19	Failure						
1975	Aravallikavu	I/II	5	III/IV	9	III/IV	13	Failure								
1976	Kanakutha	I/II	6	III/IV	8	III/IV	16	Failure								
1978	Kanakutha	I			8	Failure										
1979	Kanakutha	I/II	6	III/IV	10	Failure										

Source For yield data - files of the Forest Department ; For site quality based on top height - Ranganathan (1981), Vasudevan (1971) and Chundamannil (1997)

4.2 Productivity in Other Divisions

So far the analysis was focussed on the productivity of teak plantations in Nilambur North and South Divisions. The productivity in Other Divisions is analysed here.

Table 4.13 shows the average yield of teak plantations in Other Divisions during the period 1954-1994. This represent 363 operations together accounting for 17131 ha from 14 forest divisions in Kerala (see Appendix 2). The total mean yield obtained was 149m^3 ha^{-1} and the MAI at 65 years was 2.287 m^3 ha^{-1} $year^{-1}$ The MAI in the lowest decile was 1m^3 ha^{-1} $year^{-1}$ and that in the highest decile was 4.813 m^3 ha^{-1} $year^{-1}$(Table 4.14). Table 4.15 reproduces the results of an earlier survey by the Kerala Forest Research Institute(1979) on yield from teak plantations in four major teak growing Forest Divisions in Kerala. It shows that Nilambur Division (presently Nilambur North and Nilambur South Forest Divisions combined) had the highest MAI among the four divisions. Although the coverage was small, the MAI of 2.604 m^3 ha^{-1} $year^{-1}$ at 55 years reported for Nilambur agrees with that obtained in the present larger survey. In Wynad, Konni and Kozhikode Divisions, the MAI was lower than that of Nilambur and ranged from 1.3 to 2.5 $m^3ha^{-1}year^{-1.}$ Table 4.16 shows the average site quality based on the actual yield obtained. The average site quality based on the mean yield was only IV. The site quality classes based on the yield from highest and lowest deciles were II/III and 'failure' respectively.

Table 4.13

Average yield from teak plantations in Other Divisions worked during the period 1954 to 1995

Type of work	Mean age	No of plantations	Total area (ha)	Yield (m^3/ha)			
				Mean	CV(%)	Min	Max
1M	6	29	1445.756	3.495	88.8	0.177	12.309
2M	9	49	2500.166	3.717	80.7	0.402	11.926
1S	14	63	3586.578	3.846	87.3	0.319	17.911
2S	23	81	4112.979	5.774	97.3	0.729	36.114
3S	32	68	2938.354	6.604	73.3	1.522	23.068
4S	45	48	1910.260	13.319	72.9	2.207	51.174
FF	65	25	636.627	111.888	43.5	52.813	232.420
Total		363	17130.720	148.643		58.169	384.922
MAI at 65 Year s (m^3/ha/yr)				2.287		0.895	5.922

Source Computed from data collected from files of the Forest Department

Table 4.14

Mean, Low and High yields from teak plantations in Other Divisions

Type of work	Yield (m^3/ha)		
	Mean	Low*	High*
1M	3.495	0.243	10.487
2M	3.717	0.838	8.957
1S	3.846	0.401	13.272
2S	5.774	0.879	14.413
3S	6.604	1.736	17.422
4S	13.319	3.405	36.485
FF	111.888	58.184	211.817
Total	148.643	65.686	312.853
MAI at 65 Years	2.287	1.011	4.813

* 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

Table 4.15
Yield from teak plantations in different Forest Divisions

Division	Age at final felling	Total yield m^3/ha	MAI m^3/ha/yr
Nilambur	55.0	143.208	2.604
Wynad	70.5	177.493	2.518
Konni	70.4	164.681	2.339
Kozhikode	70.0	92.093	1.316

Source KFRI (1979)

Table : 4.16
Average yield of teak plantations and site quality observed in Other Divisions

Type of work	No. of Plant-ations	Mean age	Total area (ha.)	Mean		Lowest decile		Highest decile	
				Yield (m^3/ha)	S.Q.	Yield (m^3/ha)	S.Q.	Yield (m^3/ha)	S.Q.
1M	29	6	1445.756	3.495	III/IV	0.243	Failure	10.487	III/IV
2M	49	9	2500.166	3.717	Failure	0.838	Failure	8.957	III/IV
1S	63	14	3586.578	3.846	Failure	0.401	Failure	13.272	III
2S	81	23	4112.979	5.774	IV	0.879	Failure	14.413	III
3S	68	32	2938.354	6.604	IV	1.736	Failure	17.422	II
4S	48	45	1910.260	13.319	I/II	3.405	IV	36.485	I
FF	25	65	636.627	111.888	III/IV	58.184	Failure	211.817	II
Total	363		17130.72	148.643	IV	65.686	Failure	312.853	II/III

4.3. Productivity in Kerala

In the preceding section, the productivity in Nilambur Divisions which currently follow a 50 year rotation and Other Divisions which follow a

rotation of 60 to 70 years were analysed separately. The data from Nilambur Divisions and Other Divisions were pooled together to cover the entire state and the productivity status is presented in Table 4.17. Data from 671 plantations covering 27,319 ha were used for the analysis. The mean rotation age is 58 years and the total yield is 145 m^3ha^{-1} The MAI at 58 years is 2.497 m^{-1} $ha^{-1}yr^{-1}$ The high variability in the yields can be seen from the minimum and maximum total yields which are 33 and 400 m^3 ha^{-1} respectively. The mean total yields in the lowest deciles is 53 m^3ha^{-1} and that in the highest decile is 311 m^3ha^{-1} (Table 4.18). Table 4.19 shows the average yield of the teak plantations in Kerala and the site quality assessed based on actual yield. Considering the mean total yield, site quality observed is III/IV. Even for the plantations with yield in the highest decile, the site quality attained is only II

Table 4.17
Average yield from teak plantations in Kerala obtained during the period 1954 to 1995

Type of work	Mean age	No of Plant-ations*	Total area (ha)	Yield (m^3/ha)			
				Mean	CV(%)	Min	Max
1M	6	55	2334.321	3.931	78.0	0.177	12.309
2M	9	92	4406.370	4.702	61.3	0.402	14.801
1S	14	120	5998.101	4.427	74.6	0.215	17.911
2S	21	83	4502.802	5.401	93.6	0.110	36.114
3S	29	119	4508.084	10.318	77.0	1.522	35.749
4S	42	134	3739.563	14.442	58.2	2.207	51.174
FF	58	68	1829.923	101.612	46.0	28.623	232.420
Total		671	27319.164	144.834		33.256	400.478
MAI at 58 Years (m^3/ha/yr)				2.497		0.573	6.905

* As the age limits considered are different (see Appendix 5), 64 plantations have been excluded here.

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

Table 4.18

Mean, low and high yields from teak plantations in Kerala during the period 1954 to 1995

Type of work	Yield (m^3/ha)		
	Mean	Low*	High*
1M	3.931	0.358	10.595
2M	4.702	1.142	10.115
1S	4.427	0.405	11.637
2S	5.401	0.284	13.565
3S	10.318	2.113	23.862
4S	14.442	3.900	34.236
FF	101.612	44.409	207.153
Total	144.833	52.611	311.163
MAI at 58 Years	2.497	0.907	5.365

* 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

Table : 4.19

Average yield of teak plantations and site quality observed in Kerala

Type of work	No.of Plant-ations	Total area (ha.)	Mean age (yrs)	Mean		Lowest decile		Highest decile	
				Yield (m^3/ha)	S.Q.	Yield (m^3/ha)	S.Q.	Yield (m^3/ha)	S.Q.
1M	55	2334.321	6	3.931	III/IV	0.358	Failure	10.595	III/IV
2M	92	4406.370	9	4.702	Failure	1.142	Failure	10.115	III/IV
1S	120	5998.101	14	4.427	Failure	0.405	Failure	11.637	III/IV
2S	83	4502.802	21	5.401	IV	0.284	Failure	13.565	III
3S	119	4508.084	29	10.318	III	2.113	Failure	23.862	I/II
4S	134	3739.563	42	14.442	I/II	3.900	IV	34.236	I
FF	68	1829.923	58	101.612	III/IV	44.409	Failure	207.153	I/II
Total	671	27319.164		144.833	III/IV	52.611	Failure	311.163	II

4.4 Comparison of productivity

The mean yield of teak plantations in Nilambur Divisions, Other Divisions and for the entire state along with MAI and their respective site qualities are presented in Table 4.20.

Table 4.20
Productivity of teak plantations in Nilambur Divisions, Other Divisions and Kerala

Particulars	Nilambur Divisions	Other Divisions	Kerala
Mean rotation age (in years)	53	65	58
MAI ($m^3 ha^{-1} year^{-1}$)	2.854	2.287	2.497
Site quality based on actual mean yield and rotation age	III/IV	IV	III/IV

As can be seen, the site quality based on actual yield is better in Nilambur than that of the Other Divisions. It may be noted that even with a higher rotation age, the MAI in Other Divisions is lower than that in Nilambur. It indicates that on an average, Nilambur teak plantations have a higher productivity. Overall it clearly indicates that there is considerable scope and need for improving the productivity of teak plantations in Kerala.

Chapter 5

PROFITABILITY OF TEAK PLANTATIONS

In this chapter, 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.

5.1. Cost of cultivation and valuation of outputs

Cost include 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 m^3 was multiplied by the respective yields.

The average price of teak for different girth and quality classes during 1995 is given in Table 5.1. Teak logs and poles are classified according to girth and quality classes. Appendix 4 gives the girth limits and quality specifications used by the Forest Department for timber and poles. The prices given in Table 5.1 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 m^3 Appendix 8 gives the conversion factors in terms of number of poles equivalent to $1m^3$ of poles. For one m^3 of teakwood the prices range from Rs. 2400 to 45,400. The price 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 making electric switch boxes, photo frames etc and not used as fuel.

Table 5.1

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, Other Divisions and Kerala is presented in Appendix 9, 10 and 11 respectively. The percentage distribution of the same for Nilambur Divisions is given in Appendix 12 and that for Other Divisions in Appendix 13.

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

5.2. Profitability in Nilambur Divisions

Table 5.2 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 plantations 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 5.2
Cashflow from teak plantations in Nilambur Divisions with mean 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	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

Type of work	Age (Yr)	Cost (Rs)	Benefit (Rs)	Net benefit (Rs)
	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
	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 year to Rs. 2.28 lakhs during 4th silvicultural thinning in the 41st year. The final 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 5.2. 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 year. 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 14 and 15 shows the cash flow from teak plantations in Nilambur Divisions with low and high yields respectively.

Tables 5.3, 5.4 and 5.5 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 5.3
NPV and B/C ratio at different discount rates and IRR of teak plantations in Nilambur Divisions without land rent

Yield m^3/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 5.4
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 5.5
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	0.973	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	0.9	16.9
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 31% 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. 1300 ha^{-1} $year^{-1}$ is considered, the profitability of plantations with low yield is 7.8% (Table 5.4). Even with a higher land rent of Rs. 2500, the profitability of plantations with low yield is 6% (Table 5.5). 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 18% with a land rent of Rs.2500.

Table 5.6 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 5.6
Maximum land rent possible in Nilambur Divisions for teak plantations under different discount rates (Rs/ha)

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

5.3 Profitability in Other Divisions

Table 5.7 shows the cash flow from teak plantations in Other Divisions with mean yield. (Appendix 16 and 17 show the cash flow from teak plantations in Other Divisions with low and high yields respectively). Compared to Nilambur Divisions, the mean rotation age is longer. The costs are therefore spread out over 65 years. The total costs per hectare is Rs.1,04,000. It may be noted that the average cost does not vary markedly from that of Nilambur even though the rotation age is different. This is because current prices are used for both cases and the number of operations are also same.

The average benefit per ha from teak plantations in Other Divisions is Rs.20 lakhs. It can be seen that as the rotation age is longer, the thinning cycle is also spread out.

Table 5.7 shows the cash flow from teak plantations in Other Divisions. Here also, it can be seen that the first mechanical thinning at the 6^{th} year fetches a revenue which exceeds the accumulated costs. The net benefits at the end of 65 years is Rs.18,91,000.

As in the case of Nilambur Divisions, profitability analysis has been done with two levels of land rent and without land rent. Table 5.8 shows the NPV and B/C ratio at different discount rates and IRR for teak plantations in Other Divisions without considering land rent. Plantations with mean yields show a B/C ratio above 1 even when a discount rate of 18% is considered. But when the yield in the lowest decile is taken, a discount rate above 6% brings the B/C ratio below 1 which makes it unprofitable. The IRR of teak plantations for the mean yield is 22.8% ranging from 7.5% for the lowest decile to 44.4% for the highest decile. When the land rent at the rate of Rs.1300 is considered (Table 5.9) the IRR for plantations with mean yield reduces to 13.9%. When the land rent is Rs.2500 per ha the IRR further reduces to 9.6% (Table 5.10). With a land rent of Rs.2500 the NPV becomes negative for the lowest decile at 6% rate of discount.

Table 5.7

Cashflow from teak plantations in Other Divisions with mean 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	2475.60	18789.96	16314.36
	7	358.00	0.00	-358.00
	8	358.00	0.00	-358.00
2 Mech. thinning	9	1999.93	25767.23	23767.30
Tending	10	2628.00	0.00	-2628.00
	11	358.00	0.00	-358.00
	12	358.00	0.00	-358.00
	13	358.00	0.00	-358.00
1 Silvi. thinning	14	1934.30	29927.66	27993.37
	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
	19	358.00	0.00	-358.00
	20	358.00	0.00	-358.00
	21	358.00	0.00	-358.00
	22	358.00	0.00	-358.00
2 Silvi. thinning	23	4042.27	52616.95	48574.68
	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
	28	358.00	0.00	-358.00
	29	358.00	0.00	-358.00
	30	358.00	0.00	-358.00
	31	358.00	0.00	-358.00
3 Silvi. thinning	32	4011.56	75050.74	71039.18
Loranthus cutting	33	1093.00	0.00	-1093.00

Type of work	Age (Yr)	Cost (Rs)	Benefit (Rs)	Net benefit (Rs)
	34	358.00	0.00	-358.00
Climber cutting	35	462.00	0.00	-462.00
	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
	41	358.00	0.00	-358.00
	42	358.00	0.00	-358.00
	43	358.00	0.00	-358.00
	44	358.00	0.00	-358.00
4 Silvi. thinning	45	14511.28	131271.42	116760.14
Loranthus cutting	46	717.00	0.00	-717.00
	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
	53	358.00	0.00	-358.00
	54	358.00	0.00	-358.00
	55	358.00	0.00	-358.00
	56	358.00	0.00	-358.00
	57	358.00	0.00	-358.00
	58	358.00	0.00	-358.00
	59	358.00	0.00	-358.00
	60	358.00	0.00	-358.00
	61	358.00	0.00	-358.00
	62	358.00	0.00	-358.00
	63	358.00	0.00	-358.00
	64	358.00	0.00	-358.00
Final felling	65	36456.31	1662054.57	1625598.26
Total		104348.24	1995478.53	1891130.29

Table 5.8
NPV and B/C ratio at different discount rates and IRR of teak plantations in Other Divisions without land rent.

Yield m^3/ha/yr		Discount rate								IRR (%)
		6%		9%		12%		18%		
		NPV	BCR	NPV	BCR	NPV	BCR	NPV	BCR	
Low	1.011	13	1.6	-6	0.6	-9	0.4	-10	0.2	7.5
Mean	2.287	89	4.5	33	2.7	16	2.0	4	1.3	22.8
High	4.813	248	7.8	117	5.5	70	4.3	33	3.1	44.4

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

Table 5.9
NPV and B/C ratio at different discount rates and IRR of teak plantations in Other Divisions with land rent Rs. 1300/ha

Yield m^3/ha/yr		Discount rate								IRR (%)
		6%		9%		12%		18%		
		NPV	BCR	NPV	BCR	NPV	BCR	NPV	BCR	
Low	1.011	-10	0.8	-22	0.3	-21	0.2	-18	0.1	5.3
Mean	2.287	66	2.4	18	1.5	4	1.1	-4	0.8	13.9
High	4.813	226	4.8	101	3.4	58	2.7	25	2.0	34.4

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

Table 5.10
NPV and B/C ratio at different discount rates and IRR of teak plantations in Other Divisions with land rent Rs. 2500/ha

Yield m^3/ha/yr		Discount rate								IRR (%)
		6%		9%		12%		18%		
		NPV	BCR	NPV	BCR	NPV	BCR	NPV	BCR	
Low	1.011	-31	0.5	-36	0.2	-33	0.1	-26	0.1	4.1
Mean	2.287	46	1.7	3	1.1	-7	0.8	-12	0.6	9.6
High	4.813	205	3.6	87	2.5	47	2.1	17	1.5	27.9

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

The maximum land rent possible in teak plantations in Other Divisions which represents the maximum surplus is shown in Table 5.11. Considering a discount rate of 12%,the maximum surplus that can be obtained for plantations with mean yield is Rs. 1750. For plantations in the lowest decile the surplus is negative or nil.

Table 5.11
Maximum land rent possible in Other Divisions for teak plantations under different discount rates (Rs/ha)

Yield level	Discount rates			
	6%	9%	12%	18%
Low	750	-490	-990	-1480
Mean	5250	3000	1750	750
High	14500	9750	7750	5250

5.4 Profitability in Kerala

Table 5.12 shows the cash flow from teak plantations in Kerala with mean yield. The cash flow from plantation with low and high yield is given in Appendix 18 and 19 respectively. In the plantations with mean yield the total cost is Rs. 1 lakh, the total benefit is Rs. 19 lakhs and the net benefit is Rs. 18 lakhs in a rotation of 58 years.

Table 5.12
Cashflow from teak plantations in Kerala with mean 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	2739.77	21132.27	18392.51
	7	358.00	0.00	-358.00
	8	358.00	0.00	-358.00
2 Mech. thinning	9	2435.04	32592.59	30157.55
Tending	10	2628.00	0.00	-2628.00
	11	358.00	0.00	-358.00
	12	358.00	0.00	-358.00
	13	358.00	0.00	-358.00
1 Silvi. thinning	14	2172.42	34437.02	32264.60
	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
	19	358.00	0.00	-358.00
	20	358.00	0.00	-358.00

Type of work	Age (Yr)	Cost (Rs)	Benefit (Rs)	Net benefit (Rs)
2 Silvi. thinning	21	3804.27	49219.05	45414.79
	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
	28	358.00	0.00	-358.00
3 Silvi. thinning	29	6066.27	117241.57	111175.30
	30	358.00	0.00	-358.00
	31	358.00	0.00	-358.00
	32	358.00	0.00	-358.00
Loranthus cutting	33	1093.00	0.00	-1093.00
	34	358.00	0.00	-358.00
Climbing	35	462.00	0.00	-462.00
	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
	41	358.00	0.00	-358.00
4 Silvi. thinning	42	15704.62	142317.44	126612.82
	43	358.00	0.00	-358.00
	44	358.00	0.00	-358.00
	45	358.00	0.00	-358.00
Loranthus cutting	46	717.00	0.00	-717.00
	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
	53	358.00	0.00	-358.00
	54	358.00	0.00	-358.00
	55	358.00	0.00	-358.00
	56	358.00	0.00	-358.00
	57	358.00	0.00	-358.00
Final felling	58	33140.98	1509406.72	1476265.74
Total		102474.36	1906346.66	1803872.31

Tables 5.13, 5.14 and 5.15 show the NPV and B/C ratio at different discount rates and IRR. The three tables show the profitablity with three options of land rent viz. without land rent, with rent Rs. 1300 and Rs. 2500.

At 12% rate of discount for the option without land rent (Table 5.13), the NPV for mean yield is Rs. 25,000. For high yield it is Rs. 80,000 and for low yield it is negative. The B/C ratio at the same rate of discount is 2.4 for mean yield. The IRR for plantation with mean yield is 26%.

Considering a land rent of Rs. 1300 ha^{-1} (Table 5.14) the IRR reduces to 17.3%. When a land rent of Rs. 2500 ha^{-1} is considered the IRR becomes 12.5% (Table 5.15). The NPV at 12% rate of discount for plantations with mean yield reduces from Rs. 25,000 without land rent to Rs. 13,000 with a land rent of Rs. 1300 ha^{-1} and further to Rs. 1000 ha^{-1} when a land rent of Rs. 2500 ha^{-1} is considered.

Table 5.16 shows the maximum land rent possible in teak plantations in government forests in Kerala under different discount rates. At 12% rate of discount the maximum land rent or surplus is Rs. 2750 for plantations with mean yield and Rs. 8750 for plantations with high yield.

Table 5.13
NPV and B/C ratio at different discount rates and IRR of teak plantations in Kerala without land rent

Yield m^3/ha/yr		Discount rate								IRR (%)
		6%		9%		12%		18%		
		NPV	BCR	NPV	BCR	NPV	BCR	NPV	BCR	
Low	0.809	18	1.9	-3	0.8	-8	0.5	-9	0.3	8.2
Mean	2.228	122	5.5	49	3.4	25	2.4	8	1.6	26.0
High	4.787	303	8.9	138	6.1	80	4.7	36	3.2	45.2

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

Table 5.14
NPV and B/C ratio at different discount rates and IRR of teak plantations in Kerala with land rent Rs.1300/ha

Yield m^3/ha/yr		Discount rate								IRR (%)
		6%		9%		12%		18%		
		NPV	BCR	NPV	BCR	NPV	BCR	NPV	BCR	
Low	0.809	-4	0.9	-19	0.4	-20	0.3	-18	0.2	5.7
Mean	2.228	100	3.0	33	1.9	13	1.4	-1	1.0	17.3
High	4.787	281	5.6	123	3.9	68	3.0	28	2.1	35.3

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

Table 5.15

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

Yield m^3/ha/yr		Discount rate								IRR (%)
		6%		9%		12%		18%		
		NPV	BCR	NPV	BCR	NPV	BCR	NPV	BCR	
Low	0.809	-25	0.6	-33	0.3	-31	0.2	-25	0.1	4.4
Mean	2.228	79	2.1	19	1.4	1	1.0	-9	0.7	12.5
High	4.787	261	4.2	108	2.9	56	2.3	20	1.6	28.8

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

Table 5.16

Maximum land rent possible in teak plantations in Kerala under different discount rates (Rs/ha)

Yield level	Discount rates			
	6%	9%	12%	18%
Low	1250	-260	-830	-1380
Mean	7250	4250	2750	1250
High	17750	11750	8750	5750

5.5. Comparison of Profitability

Profitability criteria such as IRR, BCR and NPV for mean yield for Nilambur Divisions and Other Divisions is shown in Table 5.17. It can be seen that under all criteria, Nilambur teak plantations are more profitable than teak plantations in Other Divisions although the rotation ages are different.

Table 5.17
Profitability of teak plantations with mean yield in Nilambur Divisions, Other Divisions and Kerala without land rent

Particulars	Nilambur Divisions	Other Divisions	Kerala
Rotation age (Yr)	53	65	58
IRR %	31.3	22.8	26.0
NPV @ 12% (Rs)	40,000	16,000	25,000
BCR @ 12%	3.2	2.0	2.4
Maximum land rent possible @ 12% rate of discount (Rs.)	4,500	1,750	2,750

Chapter 6

PROSPECTS OF INVESTING IN TEAK PLANTATION COMPANIES IN THE PRIVATE SECTOR

So far the analysis focused on the productivity and profitability of teak plantations in the government forests. In early 1990's private companies have also started growing teak with funds collected from the public. In this chapter, the prospects of short rotation plantations is examined and an evaluation of the claims made by some of the private sector ventures is carried out.

Several companies have come up offering attractive rates of return for investing in teak plantations in the form of teak units. They advertise extensively in the newspapers and other media. For the investors, different companies offer a range of returns including cash in the form of post dated cheques and standing teak trees. Some companies offer teak trees and the land on which it grows. Most companies have their plantations in drier parts of Tamilnadu and Andhra Pradesh. One company offers three cents of land in Ernakulam along with five teak trees for an investment of Rs.5000.

6.1 Promised returns

Cannon plantations India Ltd offers[1] a return of Rs.2,20,000 in a period of 20 years for an investment of Rs.2500. This includes a return of Rs.5000 in the 6th year from inter crops, Rs.40,000 in the 11th year from 1.13 m^3 of acacia wood, Rs.75,000 in the 16th year from 2.12 m^3 of acacia wood and Rs.1,00,000 from 1.42 m^3 of teakwood. The price of acacia wood used for the calculation of returns is Rs.35,000 per m^3 For teakwood at 20 years it is Rs.69,000 per m^3 All these returns are guaranteed by post dated cheques and ownership documents within 45 days. The company advertises that plantations are managed by experienced personnel, in company's own farm land using modern scientific techniques and claims that the plantations are insured against natural calamities such as fire, drought etc.

Pachamala Estates and Plantations Pvt. Ltd. also offers[2] teak units of Rs.500 for a return of Rs.50,000 at the 20th year. This company offers 25 cubic feet of teakwood or Rs.50,000. Apart from the returns from teak, the investor can stay in the company's resorts for three days in an year.

Tech-tona Plantations India Pvt. Ltd. offers[3] three schemes. For an investment of Rs.1200 for one teak tree, the guaranteed return in cash in the 5th, 10th, and 15th years are Rs.1200, Rs.5000 and Rs.10,000 respectively. The

[1] Malayala Manorama daily 10th June, 1994.
[2] Malayala Manorama daily 20th August, 1993.
[3] Malayala Manorama daily 2nd October, 1993.

company offers free membership in their country club when the investor visits the plantations.

Parasrampuria Plantations Ltd offers[4] Rs.375 minimum per annum from the first year to fifteenth year and an yield of 30 cft of teakwood worth Rs.50,000 in the 20th year for an investment of Rs.2500. Bliss Plantations and Hill Resorts Pvt. Ltd. offers[5] Rs.40,000 in the 20th year for an investment of Rs.495 per tree. Heggon Valley Resorts offers[6] Rs.3 lakhs at the end of 20th year for an investment of Rs.4500 for five teak trees. This offer is complementary to availing 3 days stay per year in their resort for 20 years. Prince Plantations offers[7] 0.850 m^3 of teakwood or Rs.70,000 at the end of 20th year for an investment of Rs.995.

Hill View Plantations Ltd offers 25 cft of teakwood with an expected value of Rs.64,000 at the 20th year with an investment of Rs.1000. Apart from the usual offers, a prize scheme for investors by lottery and facility for withdrawing the investment at any time is provided.

Besides the above companies, several others are also active in this field. As the offers range from cash returns to timber, farm land, time share in holiday resorts etc. it is difficult to quantify their returns.

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[4] The Hindu 24th September, 1993.
[5] The Hindu 18th July, 1993.
[6] Malayala Manorama daily 21st July, 1993.
[7] Malayala Manorama daily 12th June, 1994.

6.2 Analysis of claims

For analysis two major companies Anubhav Group and Sterling Tree Magnum (India) Ltd. (STM) were taken. The investment required per unit and the promised return from selected schemes of each company is shown in the Table 6.1. The terms and conditions of offer of both the companies were taken from their brochures.

For comparing such long term investments the deep discount bonds of two leading financial institutions were considered. They are ICICI and IDBI. The investment and promised returns for different years are shown in the Table 6.2. ICICI offers[8] a return of Rs.1,00,000 at the end of 10^{th}, 15^{th} , 20^{th} , and 25^{th} year for an initial investment of Rs.24,200, Rs. 11,750 Rs. 5750, Rs. 2750 respectively. With an initial investment of Rs.2700, IDBI on the other hand offers[9] a return of Rs.50,000 at the end of 20^{th} year or Rs.1,00,000 at the end of 25^{th} year.

[8] Malayala Manorama Daily 31 March, 1997.
[9] Offer Document dated 23 January, 1992

Table 6.1

Investment and promised returns in teak growing schemes

Company		No. of trees/Unit	Initial investment	Half yearly returns for 5 years	Return at the end of					Area of teak farm* (m^2)
					4th year	5th year	6th year	12th year	20th year	
ANUBHAV	Case 1	1	5,000	500		5,000			1,00,000	9.3
	Case 2	8	40,000	4,300		44,000			12,00,000	111.6
	Case 3	20	1,00,000	11,750		1,17,000			32,00,000	297.6
	Case 4	1	5,000		10,000				1,25,000	11.63
	Case 5	8	40,000		81,760				15,00,000	139.5
	Case 6	20	1,00,000		2,14,000				40,00,000	372.0
STM	Case 1	11	19,525				17,325	71,500	10,72,500	
	Case 2	15	26,625				23,625	97,500	14,62,500	
	Case 3	5	8,875				7,875	32,500	4,87,500	
	Case 4	2	3,550				3,150	13,000	1,96,000	

* The teak farm land is valued at Rs.1,23,500 / ha.

Table 6.2
Investments and promised returns in financial schemes

Institution		Initial investment	Return (Rs.) At the time of maturity of			
			10 Year	15 Year	20 Year	25 Year
ICICI	Case 1	2,750				1,00,000
	Case 2	5,750			1,00,000	
	Case 3	11,750		1,00,000		
	Case 4	24,200	1,00,00			
IDBI	Case 1	2,700				1,00,000
	Case 2	2,700			50,000	

Table : 6.3

NPV and BCR at different discount rates and IRR of various long tern investment schemes

Company		Discount rates								IRR
		6%		9%		12%		18%		
		NPV	BCR	NPV	BCR	NPV	BCR	NPV	BCR	
ICICI	Case 1	21	8.5	9	4.2	3	2.1	-1	0.6	15.5
ICICI	Case 2	25	5.4	12	3.1	5	1.8	-2	0.6	15.4
ICICI	Case 3	30	3.6	16	2.3	7	1.6	-3	0.7	15.4
ICICI	Case 4	32	2.3	18	1.7	8	1.3	-5	0.8	15.3
IDBI	Case 1	21	8.6	9	4.3	3	2.2	-1	0.6	15.6
IDBI	Case 2	13	5.8	6	3.3	2	1.9	-1	0.7	15.7
Anubhav Teak	Case 1	34	8.0	20	5.2	12	3.5	4	1.9	28.6
Anubhav Teak	Case 2	402	11.4	236	7.2	141	4.7	52	2.4	32.0
Anubhav Teak	Case 3	1081	12.1	637	7.6	383	5.1	145	2.6	34.1
Anubhav Teak	Case 4	42	9.4	25	5.9	14	3.9	5	2.0	27.1
Anubhav Teak	Case 5	1321	14.2	770	8.7	455	5.6	161	2.6	30.1
Anubhav Teak	Case 6	494	13.4	287	8.2	169	5.2	59	2.5	29.2
Sterling Teak	Case 1	363	19.6	208	11.6	119	7.1	36	2.8	25.9
Sterling Teak	Case 2	494	19.6	283	11.6	162	7.1	49	2.8	25.9
Sterling Teak	Case 3	165	19.6	94	11.6	54	7.1	16	2.8	25.9
Sterling Teak	Case 4	66	19.7	38	11.7	22	7.1	7	2.8	25.9

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

Table 6.3 shows profitability of different investment schemes. The IRR in investment in financial schemes ranges from 15.3 to 15.7%. In the teak growing schemes they range from 25.9 to 34.1%. However most of the returns are based on a projected yield and projected price which are not guaranteed by the companies.

At 18% discount rate, all schemes of financial companies have B/C ratios below 1. At 12% discount rates, the B/C ratios of teak growing companies range from 3.5 to 11.4. The B/C ratios of financial companies range from 1.3 to 2.2.

Both the schemes of ICICI and IDBI have a credit rating by Credit Rating Information Services of India Ltd. (CRISIL) of "AAA" (triple A) indicating highest safety with regard to timely payment of interest and principal. None of the teak growing companies shows their credit rating by an independent organisation.

It is interesting to note that while established long standing companies with high credit rating offers a return of around 15%, the teak growing companies offer almost double. The difference is that the financial companies guarantee the returns from their bonds while the teak growing companies do not.

Among the different schemes of Anubhav group and Sterling Tree Magnam, a few selected schemes are presented here for illustration. In the case of Anubhav Group, after an initial investment ranging from Rs.5000 to Rs.1,00,000, half yearly returns in post dated cheques and a lumpsum amount equal to or marginally more than the initial investment is promised at the end of fifth year. Over and above this, for one unit of Rs.5000, 1.13 m^3 of teak timber at the 20^{th} year is promised. The company projects the price of the above teakwood as Rs. 1,00,000.

In the case of STM, for an initial investment ranging from Rs.3500 to Rs.19,525 in different schemes, returns are promised at the 6^{th} , 12^{th} , and 20^{th} years on the basis of teakwood at their projected price. For an initial investment of Rs. 3550, the return promised at the end of 6^{th} year is Rs.3150, at the end of 12^{th} year is Rs.13,000 and at the end of 20^{th} year is Rs.1,96,000.

In the case of Anubhav, the initial returns up to the fifth year are guaranteed by post dated cheques. However, the return in the 12^{th} year is not guaranteed in money but only in 1.13 m^3 of teakwood of unspecified girth for each unit. In the case of STM, none of the returns is guaranteed in money terms. The returns are based on unspecified yields of teakwood in the 6^{th} and 12^{th} years and the yield of 1.06 m^3 per tree at the 20^{th} year. The projected price of 1 m^3 teakwood at the 20^{th} year is Rs.91,981.

6.3 Expected yields as per All India Yield Tables.

The age of final felling or rotation is fixed taking into account the objectives of management. For pulpwood plantations, the rotation is fixed on the basis of maximum volume production. For fast growing species if there is no distinction between heartwood and sapwood and between different girth classes as in pulping, a very low rotation age is preferred. But for purpose such as furniture, veneers, plywood, construction etc., large sized logs are required. Further, there is a steep price-size gradient for species such as teak. Logs of small diameter fetch very low price compared to larger diameter classes(See Table 5.1).

Table 6.4
Rotation for maximum volume production (age in years)

Category	Site quality			
	I	II	III	IV
Stem wood and small timber	5-10	5-10	5-10	15
Stem wood	50	75	80	80

Source FRI & C (1970)

When the objective of managing a teak plantation is to maximise the production of stem timber, the rotation age ranges from 50 years for site quality I to 80 years for site quality IV (Table 6.4). When no distinction is made between stem timber and small wood such as for pulpwood or firewood, a short rotation of 5 to 15 years is feasible.

Teak timber is conventionally classified as stemwood and small timber. Stemwood denotes logs above 60cm mid-girth under bark. The higher the girth, the higher is the quality class of timber. Stemwood from 60 to 74 cm girth which is the same as diameter of 19.1 to 23.6 cm belongs to only IVth class logs. For first class log, the diameter limits are 47.4 to 57.3 cm. and for export quality class, the diameter has to be above 57.3 cm. (See Appendix 4).

Table 6.5 shows the average diameter of trees in different site quality classes. At 20 years, the average diameter of a teak tree ranges from 10.9 to 27.2 cm. Even at the age of 50 years and site quality I, the average diameter of a tree is 55.4 cm which is lower than the minimum for the export quality logs. At 20 years, even in site quality I, the average diameter is not even half that of export quality logs.

Table 6.5
Average diameter of teak trees in different site quality classes

Age	Diameter (in cm) in site quality classes			
	I	II	III	IV
20	27.2 (0)*	19.8 (0)	14.7 (0)	10.9 (0)
50	55.4 (36)	39.9 (2)	26.4 (0)	17.0 (0)
60	60.7 (59)	45.0 (4)	30.0 (0)	19.0 (0)
70	65.3 (80)	49.3 (8)	33.3 (0)	20.8 (0)
80	69.8 (88)	53.8 (25)	36.8 (0)	22.9 (0)

* The figures in parenthesis are percentage number of trees having export size girth above 180 cm

Source Tewari, 1992.

It is obvious from the Table that at 20 years, no tree attains the girth of export size logs. Even at a rotation age of 80 years in site quality I, where the average diameter is 69.8 cm, the percentage number of trees above 57.3 cm diameter is only 88.

Table 6.6

Distribution of final yield in timber and small wood for different rotation ages

Age	Yield (in m3) in different site quality classes											
	I			II			III			IV		
	Timber	Small wood	Total	Timber	Small wood	Total	Timber	Small wood	Total	Timber	Small wood	Total
20	57.038	64.935	121.973	23.400	75.465	98.865	5.265	58.500	63.765	0.000	34.515	34.515
	(46.76)*	(53.24)	(100)	(23.67)	(76.33)	(100)	(8.26)	(91.74)	(100)	(0.00)	(100.0)	(100)
50	209.138	7.605	216.743	126.943	18.428	145.373	45.923	45.630	91.553	5.265	49.725	54.930
	(96.49)	(3.51)	(100)	(87.32)	(12.68)	(100)	(50.16)	(49.84)	(100)	(9.58)	(90.52)	(100)
60	242.483	6.728	249.211	155.610	15.795	171.405	67.275	37.440	104.715	12.285	50.603	62.888
	(97.30)	(2.70)	(100)	(90.78)	(9.22)	(100)	(64.25)	(35.75)	(100)	(19.53)	(80.47)	(100)
70	269.978	6.143	276.121	179.010	14.040	193.050	89.798	32.760	122.558	22.815	50.018	72.833
	(97.78)	(2.22)	(100)	(92.73)	(7.27)	(100)	(73.27)	(26.73)	(100)	(31.33)	(68.67)	(100)

* The figures in parenthesis are distribution of total yield within a site quality

Source Tewari, 1992

Table 6.6 shows the distribution of final yield in timber and small wood for different rotation ages. The logic of choosing 50 years as rotation age in the government plantations is evident here. At 50 years, the percentage volume of timber in the final yield is 96.49 in site quality I. In the same site quality at 20 years, the percentage volume of timber is only 46.76. The rest of the yield is small wood. If the site quality is below I, the percentage of timber is very low. At 20 years, the percentage volume of stem timber is 23.67% in site quality II, 8.26% in site quality III and none at all in site quality IV.

As per All India Yield Tables for teak plantation at 20 years, the final yield including timber and small wood per tree ranges from 0.048 m^3 in site quality IV to 0.578 m^3 in site quality I.

6.4 Prospects

The attractive offers and high rate of returns promised by teak growing private companies have already been reviewed. Most of the companies base their calculation of returns on two crucial assumptions namely the yield per tree and its projected price in the next 20 years.

The Sterling Tree Magnum guarantees a final yield of 1.06 m^3 per tree at the age of 20 years. Anubhav Group guarantees a final yield of 1.13 m^3 per tree at 20 years. Whereas the assumed yield of both the companies is almost double of 0.578 m^3 per tree, indicated in the All India Yield Tables for teak

plantations in site quality I. It may be recalled that the mean site quality attained in the world famous Nilambur teak plantations is only III/IV and even when the yield in the highest decile is considered, the site quality is only II/III. The areas where teak is now raised by private plantation companies in Tamil Nadu cannot be compared with the site potential of the natural teak growing forests of Nilambur. It is doubtful whether the guaranteed yield can be obtained from each tree. Even if the projected yields are realised with high inputs and technology, the proportion of stem timber in the final yield cannot be more than half of the total yield at 20 years. The stem timber obtainable at 20 years is likely to be of log girth class IV or at the maximum girth class III.

The problem of water blister in teak trees growing near water courses is already reported (Kallarackal *et al.*, 1992). Insect pests that reduce the annual volume increment continues to plague teak plantations (Nair *et al.* 1985). Diseases such as stem canker, caused by pathogens that kills the shoot above the point of infection, in high input teak plantations are being investigated by the Kerala Forest Research Institute. All these indicate that addition of nutrients and irrigation may be insufficient to ensure high output of quality teakwood.

There is a consensus of opinion regarding the positive effect of irrigation and fertilisers on plantation growth. Reddy (1995) reports impressive growth of teak in Haldwani division of U.P. due to the effect of irrigation. He reports that the 21 year old plantation attained a diameter of

34.5 cm. Rawat (1995) is optimistic that an irrigated 20 year old plantation can attain the growth of a 25 year old unirrigated plantation. Better survival rates and higher initial growth are also predicted. Gogate *et.al* (1995) also affirms the positive response to irrigation and fertilisers in teak plantations. However, he adds that continuous monitoring of the response to irrigation has revealed that except during the juvenile stage there is lack of response to irrigation during the winter months ie. period of dormancy. On the basis of his studies he rejects claims of spectacular growth round the year with higher inputs. Haque (1996) discusses the economic effect of intensive irrigated teak plantations and concludes that teak raised under irrigation will lose the decorative quality for which teak is famous. However, he adds that teakwood of any quality would have a ready market in a wood starved situation. Chaturvedi (1995) is positive on the impact of irrigation and frequent thinnings on the diameter growth in teak plantations. He clarifies that increase in diameter growth is dependent on increase in the size of the crown which means decrease in the number of trees per hectare. The problem he identifies is that the size of the trees and the number of trees cannot be increased simultaneously as some teak growing companies claim. Teak does not grow well on degraded lands and water logged sites.

In contrast to these, Rajan and Sunder (1996) spokespersons for STM plantations claimed that it is possible to get 180 teak trees per acre (445 trees per ha) with 150 cm girth at breast height within 20 years based on the performance of teak trees grown in Tanjore area of Tamil Nadu as line

plantations along irrigation canals. They claim to have a package of high input practices that include best quality seeds, micro-irrigation, liquid fertilisation, integrated pest management and intensive plantation management.

In the case of private plantations, the question whether the projected yields are realistic is to be examined. Karunakaran (1995) joins issue with a company that claims it will grow 1250 teak trees per ha providing $1m^3$ of timber from each tree in the 20^{th} year. He points out that to obtain $1m^3$ of timber from each tree, it is not possible to grow more than 250 to 280 trees in a hectare. Kinhal (1995) criticises the claims of some companies to get Rs. 1,00,000 for a teak tree after 20 years. He points out that in 20 years what can be obtained is only a pole and not a full grown tree.

Krishnamurthy (1991), a senior forester of long standing, is skeptical of even getting Rs. 50,000 per tree in 20 years and asserts that such claims by private companies are myths. He argues that the site potential for a particular species cannot be increased beyond the indicated capacity of the site. The economic return from a teak plantation will depend on the percentage of stem timber and small wood in the final yield. The younger the plantation, the smaller is the quantity of stem timber. Chathurvedi (1995), an authority on silviculture, also rejects such claims as impossible. Even then, for argument sake giving the benefit of doubt to these companies which claim that they use genetically superior seedling and provide inputs such as drip irrigation,

fertilisers and intensive management, the value of such timber is expected to be lower than that of slow grown teak.

The returns are promised in the form of teakwood (around 1.1m^3) at the end of 20 years. It is not specified whether it includes all the woody biomass including bark, twigs etc. The forest department considers only timber above 60 cm girth under bark as commercial volume of timber. Even in a mature tree the commercial volume comes to only less than 60% of the total over-bark wood volume. In younger trees, the proportion of commercial volume of timber is much lower. Teak prices have been projected at 6% compound rate for 20 years to get the projected price by the teak companies. It seems to be a reasonable rate. However the base price used is not of the log girth class IV or III. They have used the price of export size high quality logs as the base price for the projection. Using the price of superior quality commercial logs for a total volume is inappropriate. If either the yield is not attained or the projected price is not realised, the investor will be left with an empty promise.

The rate of return from teak plantations in the private sector shown in this chapter depends heavily on the assumptions regarding the yield and price projection. As the yield guaranteed and the prices used being inappropriate considering the All India Yield Tables for teak and the composition of final yield, the rate of return appears to be exaggerated.

Chapter 7

DISCUSSION

In this chapter, a further discussion on the changes in productivity in government teak plantations is made. As profitability depends on productivity, the discussion is limited to productivity. Some issues in plantation management is also reviewed here.

7.1 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 7.1 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 intervals based on the year of planting sequentially and the mean site quality based on yield obtained is shown as a percentage.

Table 7.1

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	90.600	0	0	0	80	20
	1970 - 74	6	264.247	0	0	18	82	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	38	62
	1960 - 64	15	628.400	0	0	0	100	0
	1965 - 69	4	203.540	0	0	0	100	0
	1970 - 74	5	249.421	0	0	23	58	19
	1975 - 79	12	572.969	0	0	5	56	39
	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	97	3
	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	40	60
	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	4	66	31
	1955 - 59	13	598.327	0	0	0	72	28
	1960 - 64	2	466.000	0	0	0	0	100
	1965 - 69	4	113.250	0	0	0	79	21
	1970 - 74	9	395.027	0	0	6	12	82
3S	1935 - 39	13	339.100	0	100	0	0	0
	1940 - 44	16	528.200	0	77	11	12	0
	1945 - 49	20	605.710	0	53	12	25	10
	1950 - 54	4	92.230	0	0	0	100	0
	1960 - 64	11	505.970	15	0	11	46	28
4S	1930 - 34	20	365.800	92	7	1	0	0
	1935 - 39	19	654.480	35	10	15	40	0
	1940 - 44	2	74.980	0	0	70	30	0
	1950 - 54	5	125.903	0	0	27	46	27
FF	1930 - 34	7	135.237	0	0	16	28	55
	1935 39	7	127.246	0	0	6	38	55
	1940 - 44	8	143.958	7	0	14	79	0

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, 28% 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), 92% 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.

Table 7.2 presents the productivity data of teak plantations in Other Divisions in the same format as that of Table 7.1. Here also distinct shift in site quality from the better to the poorer can be observed in each operation in each successive periods. The overall inference is that the plantations raised in earlier periods had relatively better productivity levels than that raised subsequently.

Table 7.2

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

Type of work	Plantation year	No. of planta-tions.	Area (ha.)	Site quality				
				I	II	III	IV	Failure
1M	1976 - 85	25	1265.800	0	0	7	58	35
2M	1966 - 75	8	468.200	0	0	0	18	82
	1976 - 85	38	1899.250	0	0	0	29	71
1S	1966 - 75	24	1250.840	0	0	5	22	73
	1976 - 85	34	1913.350	0	0	0	1	99
2S	1956 - 65	25	1643.340	0	0	1	67	32
	1966 - 75	51	2214.630	1	0	2	34	63
3S	1946 - 55	12	378.170	14	16	7	42	21
	1956 - 65	52	2337.660	0	1	14	53	32
4S	1936 - 45	23	731.200	44	26	10	18	2
	1946 - 55	20	825.978	6	44	18	28	4
FF	1916 - 25	14	313.347	0	21	39	31	9
	1926 - 35	10	305.680	0	0	36	41	23

Another exercise was done using the period of working as a criterion for observing the changes in productivity levels. Table 7.3 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 47% belonged to site quality III. No plantations existed in the 'failure' category. During 1990-94, 65% of the area of plantations finally felled belonged to site quality IV and 23% came in the 'failure' category. Table 7.4 shows similar classification of plantations in Other Divisions based on period of working. Here also a trend similar to that of Nilambur Divisions is observed.

Table 7.3

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	18	82	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	83	17
	1970 - 74	11	494.880	0	0	0	100	0
	1975 - 79	3	173.900	0	0	0	100	0
	1980 - 84	5	215.641	0	0	27	52	22
	1985 - 89	14	609.003	0	0	5	50	45
	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	76	24
	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	19	81
2S	1965 - 69	11	236.304	0	0	7	47	46
	1970 - 74	11	371.500	0	0	0	83	17
	1975 - 79	12	960.927	0	0	0	34	66
	1985 - 89	5	135.500	0	0	16	66	17
	1990 - 94	9	378.277	0	0	0	13	87
3S	1965 - 69	18	496.200	0	76	12	12	0
	1970 - 74	17	566.800	0	85	13	2	0
	1975 - 79	18	502.240	0	42	0	46	12
	1985 - 89	7	305.205	0	10	18	46	26
	1990 - 94	5	230.765	33	0	0	41	27
FT	1965 - 69	35	509.800	90	3	7	0	0
	1970 - 74	23	434.800	93	6	1	0	0
	1975 - 79	19	592.680	40	11	17	33	0
	1980 - 84	3	142.980	0	0	37	63	0
	1985 - 89	4	115.660	0	0	30	50	21
	1990 - 94	2	33.383	0	0	69	0	31
FF	1970 - 74	9	350.219	0	26	47	27	0
	1975 - 79	13	476.789	0	12	38	50	0
	1980 - 84	5	126.405	0	0	29	48	23
	1985 - 89	10	193.446	5	0	4	47	44
	1990 - 94	10	169.985	0	0	12	65	23

Table 7.4

Percentage distribution of area of teak plantations according to year of working in Other 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	1980 - 84	12	492.450	0	0	2	97	2
	1985 - 89	11	697.440	0	0	0	39	61
	1990 - 95	4	165.916	0	0	51	49	0
2M	1970 - 74	2	116.526	0	0	0	9	91
	1980 - 84	7	350.320	0	0	0	24	76
	1985 - 89	15	1234.110	0	0	0	28	72
	1990 - 95	24	783.024	0	0	0	27	73
1S	1975 - 79	4	408.179	0	0	42	34	24
	1980 - 84	9	347.764	0	0	0	56	44
	1985 - 89	9	406.365	0	0	0	5	95
	1990 - 95	39	2347.380	0	0	0	3	97
2S	1975 79	3	121.830	0	33	37	30	0
	1980 - 84	9	784.610	0	0	0	95	5
	1985 - 89	14	613.329	0	0	2	51	46
	1990 - 95	53	2460.030	1	0	1	33	65
3S	1955 59	3	161.820	24	0	42	34	0
	1980 - 84	9	314.640	17	19	8	36	20
	1990 - 95	54	2384.750	0	1	14	54	31
FT	1975 - 79	2	226.510	100	0	0	0	0
	1980 - 84	12	409.920	54	46	0	0	0
	1985 - 89	8	260.040	8	13	36	36	6
	1990 - 95	24	915.588	17	36	14	30	4
FF	1980 - 84	3	61.373	0	52	43	5	0
	1985 89	4	133.380	0	0	45	33	21
	1990 - 95	17	424.274	0	8	34	41	16

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 and in Other 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.

7.2 Issues in management

Teak plantations are managed on a low input, low intensity management in the government forests. Several reasons can be attributed to the low productivity levels in teak plantations. The quality of the planting stock, timely planting, initial care, appropriate thinning schedule and intensity and management care are the most important factors that contribute to the success of teak plantations.

Seed stands have been established in various divisions for obtaining seeds. However, no seed certification procedures are followed in Kerala and no strict screening of the planting material is carried out at the time of planting. Often, timely planting is not possible due to inappropriate procedures in the release of funds and delayed planting results in poor initial growth and smothering of teak plants by weeds. As the taungya system has been given up in teak plantations, keeping the plantation well weeded is very difficult task. Thinnings also get delayed due to various reasons resulting in overstocking and low diameter increment.

To keep down weeds and for casualty replacement, plantation sites were leased out for growing agricultural crops such as paddy, sesamum, tapioca etc. Problems of soil erosion due to intensive soil working and the digging up of tuber crops (Alexander *et al.,* 1980*)* have led to abandoning the taungya system in plantations. When the taungya system was in vogue, the forest department obtained a revenue from the taungya contractor and got all the initial maintenance work and fire protection done free of cost. Now, without taungya three to four weedings are prescribed in the first year and two to three weedings in the next two years. In practice, however, departmental weeding is not always effective in controlling weeds.

The close spacing is adopted to obtain a clear bole and to keep down weeds. Periodic thinning operations are prescribed to allow the crown to develop and to prevent root competition. Teak does not tolerate shade and once a tree is suppressed it will remain stunted. Delayed thinning which is a common feature in Kerala adversely affects the timber output from teak plantations.

Plan funds were provided for initial plantation work only and not for subsequent maintenance of the plantations. Allocation of plan funds depends on the level of achievement in spending the past year's allotment. In order to secure the maximum plan funds the plantation programme expanded (Viswanathan, 1992). Along with this, the backlog of cultural operations,

thinning etc. also accumulated. The problem has been accentuated by the financial crisis prevailing in the State for the past few years. Due to treasury restrictions and ban on expenditure, except items specifically exempted, time bound and seasonal field operations of the Forest Department get seriously affected (Manoharan, 1990).

The greatest achievement of forestry in Kerala is creation and expansion of plantations. An extensive asset base has been created. However, the success of teak plantations has been taken for granted; the deterioration of quality, perhaps, due to the expansion to the marginal areas or, due to deficiency in management has not been addressed seriously. Despite Kerala's early start and achievements, the average quality of the teak plantations is far from satisfactory.

In a review of teak plantation management in Kerala, it was noticed that after the initial success in plantation raising, the progress was confined to cost reduction measures and that no improvement in plantation technology has been made (FAO, 1984). An analysis of the investment pattern in forests showed low level of investment in plantations and that the priority was for investments with quick returns (Chundamannil, 1986).

The High Level Expert Committee has observed that "although the technique of teak regeneration is well known, there has been no technological advance in the recent past" (Menon, 1986). An International Teak

Symposium was organised by the Kerala Forest Department in 1991 at Trivandrum. In a review of the status of teak in Kerala, it was reported that "high targets in teak plantation programme has persuaded the Kerala Forest Department to establish plantations in unsuitable sites" (Basha and Sankar 1991:16). On the future of teak in Kerala forests, a sceptic scenario was presented, given that the site quality distribution is skewed to the lowest classes and more plantations are in age groups below 30 years (planted on unsuitable sites); the yield from teak is expected to decline progressively.

Second rotation plantations in Nilambur Divisions faced certain problems and there was wide discussion on the deterioration of site quality in successive rotations. Champion, the Central Silviculturist, brought out a bulletin on the problem of pure teak plantations (Champion 1932). In this report, although the problem of site deterioration was acknowledged, the practical approach recommended was to ignore this issue, as even poor quality teak plantations were superior to any other species on economic grounds. The silvicultural conferences, subsequently reiterated the recommendations for maintaining undergrowth, leaving a patch of natural forests around plantations and fire protection to reduce the problem of site deterioration in teak plantations.

A recent study by KFRI which sampled a cross-section of teak plantations in different age groups throughout Kerala observed that the younger plantations showed high site quality while it declined with age. This

may be an indication that even within a rotation, the site quality may deteriorate (Jayaraman 1995). Conflicting opinions continue to prevail on the question of site deterioration in teak plantations. The problem was acute where sufficient undergrowth was absent and where fire protection was neglected. The growth of teak deteriorated when plantations were extended up the slope and in lateritic areas. Although soil erosion in teak plantations has not been quantified in Kerala, annual erosion losses upto 152 tonnes per ha of soil has been reported from teak plantations in Trinidad while it was only 17 tonnes in the adjoining natural forests (Evans 1982).

The mismatch between the site quality based on top height and the yields cannot be easily explained. Three reasons for the same can be considered. The first is that the yield is very much dependent on optimum stocking and site quality based on top height simply assumes optimum stocking. A recent survey showed that 64% of all the teak plantations in Kerala are understocked. In Nilambur 49% of the teak plantations are understocked (KFRI, 1997). The second possibility is that there is site deterioration even within a rotation. A fall in the rate of growth and general health of plantations in Nilambur at about 18 to 20th year has been reported in the third Silvicultural Conference (FRI and C, 1929). Davis (1940) also reported that certain teak plantations in Nilambur tend to stagnate after a good initial growth. The third possibility is that the entire thinning yield may not be brought to the market and sold. Hence the recorded yield may be less than the actual yield. Labour charges being quite high in Kerala, thinned

material from inaccessible areas may be left to rot in the field. Some pilferage of timber may also be possible due to lack of effective management and thereby the recorded yields are low.

Currently, teak plantations are site quality mapped between the ages of 10 and 25. This is done during the revision of Working Plans on the basis of top height of the crop. Due to high variability in stocking and other factors, the yield obtained is often much lower than that could be expected at the particular site quality level. It would be more useful if the site quality determination takes into account the level of stocking and basal area to arrive at a yield class level for each plantation. Further, there are some indications of changes in productivity level over time. Therefore, a periodic review of the productivity status of each plantation during the revision of the Working Plans every 15 years would be useful to monitor the performance of teak plantations and to enable the introduction of realistic yield regulation systems.

Chapter 8

SUMMARY AND 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 government forests. In this study, productivity and profitability in government teak plantations in Kerala 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. The mean total yield in Other Divisions in a rotation of 65 years was 148.643 $m^3 ha^{-1}$ and the MAI was 2.287 $m^3 ha^{-1} year^{-1}$ The mean total yield and MAI for Kerala as a whole were 144.833 $m^3 ha^{-1}$ and 2.497 $m^3 ha^{-1} year^{-1}$ respectively in a mean rotation of 58 years.

For plantations in site quality class I, the expected MAI at 53 years is 8.210 $m^3 ha^{-1} year^{-1}$ and for site quality IV plantation, it is 1.780 $m^3 ha^{-1} year^{-1}$ according to the All India Yield Tables for teak. The MAI obtained in Nilambur is equivalent to the yield expected in site quality class III/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 average site quality based on the mean yield in Other Divisions was only IV while the site quality based on yield from highest and lowest deciles was II/III and far below the lowest class respectively.

Based on the actual yield, the mean site quality observed in Kerala was equivalent to III/IV class. The site quality in the highest and lowest deciles were II and far below the lowest class respectively. It is seen that the site quality was better in Nilambur than that in Other Divisions. It is found that even with a higher rotation age, the mean yield in Other Divisions was lower than that in Nilambur. This indicates that on the average, Nilambur teak plantations have a higher productivity.

The financial 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 (IRR) is 31.3%. This means that the 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 was 11.7 %. When a land rent of Rs. 1300 ha^{-1} $year^{-1}$ is considered, the profitability

of plantations having low yield 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 only 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.

Profitability analysis of teak plantations in Other Divisions with mean yield without considering land rent showed a BCR above 1 even when a discount rate of 18% was considered. But when the yield in the lowest decile was taken, a discount rate at 9% brought the BCR below 1 which makes it unprofitable. The IRR of teak plantations for the mean yield was 22.8% ranging from 7.5% for the lowest decile to 44.4% for the highest decile. For plantations with mean yield, when the land rent at the rate of Rs.1300 was considered, the IRR was reduced to 13.9%. When the land rent was Rs.2500 ha^{-1}, the IRR was further reduced to 9.6%. With a land rent of Rs.2500, the NPV became negative for the lowest decile at 6% rate of discount. The maximum land rent possible in teak plantations in Other Divisions with mean

yield is Rs.1750 at a discount rate of 12%. For plantations in the lowest decile, the surplus is negative or nil.

Profitability analysis of teak plantations in Kerala with mean yields without considering land rent showed a BCR of 1.6 even when a discount rate of 18% was considered. But when the yield in the lowest decile was taken, a discount rate at 9% brought the BCR below 1 which makes it unprofitable. The IRR of teak plantations for the mean yield was 26.0% ranging from 8.2% for the lowest decile to 45.2% for the highest decile. When the land rent at the rate of Rs.1300 was considered, the IRR for plantations with mean yield reduced to 17.3%. When the land rent was Rs.2500 ha^{-1}, the IRR further reduced to 12.5%. With a land rent of Rs.2500, the NPV became negative for the lowest decile at 6% rate of discount. The maximum land rent possible in teak plantations in Kerala with mean yield is Rs.2750 at a discount rate of 12%. For plantations in the lowest decile, the surplus is negative or nil at a discount rate above 9%. The profitability analysis using IRR, BCR and NPV for mean yield for Nilambur and Other Divisions showed that Nilambur teak plantations are more profitable than plantations in Other Divisions although the rotation ages are different.

Apart from the analysis on the productivity and profitability of teak plantations in the government forests, the claims made by the teak plantation companies in the private sector was evaluated. The analysis based on two major teak growing companies and two leading financial institutions showed

that the IRR in investment in financial schemes range from 15.3% to 15.7%. And in the teak growing schemes, they range from 25.9% to 28.7%. However, most of the returns are based on the projected value of teak wood of unspecified girth. The projected price is not guaranteed by the teak growing companies.

The evaluation of claims of the private teak growing companies, based on the actual performance in government forests and the expected yield according to the All India Yield Tables revealed that the projections made by the companies to attract investors are too optimistic.

The productivity achieved in government 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 government 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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GLOSSARY

Basal area: The are of the cross-section of a stem at breast-height. When applied to a crop (crop basal area), the sum of basal areas of all the stems or the total basal area per unit of area.

Bole: The main stem of a tree. Sometimes used to refer to only the lower part of the stem up to a point where the main branches are given off, i.e., as a synonym of clear or clean bole. syn. Trunk.

Breast height: Almost universally adopted as the standard height for measuring girth, diameter and basal are of standing trees 1.37m. above ground level.

Canopy: The cover of branches and foliage formed by the crowns of trees in a wood. Syn. Leaf canopy.

Clearfelling: Strictly the felling of the whole standing crop in one operation.

Clearing: An open space in the forest, due to clearing of growth.

Climber: A herbaceous or woody plant that climbs up trees or other support by twining round them or by holding on to them by tendrils, hooks, arial roots or other attachments.

Conversion: A change from one silvicultural system or one (set of) species to another.

Crop height: A term used in sample plot work and yield tables in India, and refers to the average height of a regular crop.

Cultural operations: A general term for operations, as a rule not directly remunerative, undertaken to assist or complete existing regeneration to promote the proper development of the crop. It includes weeding, cleaning, unremunerative improvement fellings and thinning.

Deciduous: Perennial plants that as are normally leafless for some time during the year.

Environment: All the biotic and abiotic factors of a site.

Epiphyte: A plant growing on, but not nourished by, another plant.

Erosion: The removal of soil and rock materials by water, wind and gravity; generally refers to accelerated erosion.

Extensive Forestry: The practice of forestry on the basis of low operating and investment costs per ha.

Financial Rotation: A rotation determined by financial considerations, e.g., that yielding the highest rate of interest.

Fireline: A cleared permanent fire break intended to prevent fires crossing from one are a to another.

Fluting: The tendency to show irregular involutions and swellings on the bole just above the base characteristic of some species, e.g., Teak. It is often unrelated to buttress formation.

Forestry: The theory and practice of all that constitutes the creation, conservation and scientific management of forests and utilisation of their resources.

Girth class: One of the intervals into which the range of girth of trees or logs is divided for classification or use; also the trees or logs falling into such an interval.

Growing stock: The sum (by number or volume) of all the trees growing in the forest or a specified part of it.

Intensive Forestry: The practice of forestry with the object of obtaining the maximum in volume and quality of products per unit of area through the application of the best techniques of silviculture and management.

Mean Annual Increment: The total increment (total volume of wood) up to a given age divided by that age.

Mid girth: The girth of a log, bole or a tree, measured half way along its length or height.

Money yield table: A table constructed from a volume yield table in which the yields are expressed in terms of money instead of volume.

Natural regeneration: The renewal of a forest crop by self-sown seed, or by coppice or root suckers; also the crop so obtained.

Outturn: (a) The quantity of produce obtained from any unit of a forest. (b) The quantity of sawn timber obtained from, a given quantity of round logs.

Rotation of the maximum volume production: The rotation that yield the greatest annual quantity of material. It coincides with the age at which the mean annual increment culminates.

Rotation: The planned number of years between the formation or regeneration of a crop and its final felling.

Selection felling: The annual or periodic removal of exploitable trees, individually or in small groups, in an unevenaged forest in order to realise the yield.

Silviculture: The art and culture of cultivating forest crops.

Site quality: A measure of the relative productive capacity of a site for a particular species. The top height as it varies with age in generally the basis for classification.

Small wood: Wood below a certain girth or diameter but often with a lower limit.

Spacing: The distance between the trees put out in a plantation or standing in a crop.

Stump: A young plant with a pruned top-root and severed stem used for planting. Syn. Stump, stump plant.

Sustained Yield Management: Management of a forest to give equal annual or periodic returns in perpetuity.

Sustained Yield: (a) The material that a forest can yield annually(or periodically) in perpetuity. (b) As applied to a policy , method or plan of management(sustained yield management), it implies continuous production with the aim of achieving, at the earliest practical time at the highest practical level an approximate balance between net growth and harvest, either by annual or somewhat longer periods.

Taungya: (Burmese; taung=hill , ya=cultivation) The term is now applied to the method of raising forest plantations in combination with field crops, otherwise known as Agri-silvicultural methods.

Technical rotation: The rotation under which a species yields most material of specified sizes and suitability for economic conversion or special use.

Thinning: A felling made in an immature stand for the purpose of improving the growth and form of the trees that remain, without permanently breaking the canopy.

Top height: (a) In general terms, it is the average height of the dominant trees in a stand. (b) As used in sample plot work and yield tables in India it refers to the height corresponding to the mean diameter (calculated from the basal area) of t he 100 biggest diameters per acre as read from the height/diameter curve.

Undergrowth: The lowest stratum of woody and other vegetation above the ground cover. Syn. Low cover.

Volume Table: A table showing for a given species the average contents of trees, logs or sawn timber for one or more given dimensions. The given dimensions may be (I) d.b.h. alone, (ii) d.b.h. and height or (iii) d.b.h., height and some measure of form or taper. Volume tables may be (I) general, (ii) regional or (iii) local, depending on the scope of their applicability.

Working plan: A written scheme of management aiming at continuity of policy and action and controlling the treatment of a forest. The instrument of forest management. Syn. Management plan. See also plan of operations(b).

Yield table: A tabular statement which summarises on unit area basis all the essential data relating to the development of a fully stocked and regularly thinned even aged crop at periodic intervals covering the greater part of its useful life. Syn. Volume yield table.

Source FRI and C, 1983.

APPENDICES

Appendix 1

Data on yield from teak plantations in Kerala used for the analysis

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 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	16.050							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	1924	Edacode	3.800						74.942	
Nilambur	1924	Valluvasseri	7.700						152.330	
Nilambur	1925	Aruvacode	6.800						133.178	
Nilambur	1925	Edacode	8.400						165.080	
Nilambur	1925	Mulathamanna	13.200						259.982	
Nilambur	1925	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	1927	Aruvacode	5.100						98.338	
Nilambur	1927	Edacode	30.000						591.775	
Nilambur	1927	Elanjeri	15.500						306.255	
Nilambur	1927	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	1927	Ramallur	5.900						116.441	
Nilambur	1928	Edacode	16.200						318.219	
Nilambur	1929	Edacode	13.000						256.092	
Nilambur	1929	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	6.200						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						596.560	1691.024
Nilambur	1933	Panangode	10.400						204.969	
Nilambur	1934	Aravallikavu	6.761						131.595	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	1935	Nellikutha	24.737						488.894	840.482
Nilambur	1936	Edacode	35.900						416.563	
Nilambur	1936	Nellikutha	27.900						254.247	
Nilambur	1937	Edacode	19.000					407.301		

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	1937	Nellikutha	36.800					788.603		
Nilambur	1937	Panangode	13.300					285.110	214.534	
Nilambur	1937	Panayangode	13.320							690.870
Nilambur	1937	Valluvasseri	8.057					172.453	647.737	940.599
Nilambur	1938	Nellikutha	74.100					1587.606	423.183	
Nilambur	1938	Pokkode	2.300					50.263	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		
Nilambur	1939	Valluvasseri	20.607					438.384		877.930
Nilambur	1940	Valluvasseri	22.794					203.892		1800.090
Nilambur	1941	Valluvasseri	9.200					197.557		
Nilambur	1942	Valluvasseri	22.348					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	1943	Valluvasseri	52.632					1140.442	578.697	
Nilambur	1944	Chathambora	40.900					875.263		
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					60.276		

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	18.300				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	51.410		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	41.050	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	250.224		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							4430.289
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	Karimpuzha	4.900						52.265	
Karulai	1931	Karimpuzha	8.500						167.483	
Karulai	1935	New Amarampalam	15.500						304.660	
Karulai	1936	New Amarampalam	13.090						211.838	

Division & Range	Plant Year	Name of Plantation	Area (ha.)	Yield in different type of operations (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	20.000				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	42.680		

Division & Range	Plant Year	Name of Plantation	Area (ha.)	Yield in different type of operations (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		94.000		726.921					
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					

Division & Range	Plant Year	Name of Plantation	Area (ha)	Yield in different type of operations (m^3)						
				1M	2M	1S	2S	3S	4S	FF
Chalakkudy										
Chimminy	1975	Muthalamkappu	76.250	258.413						
Chimminy	1978	Muthalamkappu Bit I	18.040	151.388						
Palappilly	1974	Nadampadam	78.250			303.907				
Pariyaram	1935	Rv	115.130						4136.859	
Pariyaram	1953	Kanikkollai	40.470				980.941			
Pariyaram	1954	Kanikkollai	44.510				660.259			
Pariyaram	1955	Kanikkollai	36.850				391.449			
Pariyaram	1964	Mullappana	107.930		1517.885					
Pariyaram	1965	Mullappana	138.890		1629.968		850.267			
Pariyaram	1966	Mullappana	62.680		1122.649					
Pariyaram	1969	Mullappana	43.500		392.196					
Pariyaram	1972	Mullappana	83.630		738.268					
Pariyaram	1975	Mullappana	77.200			704.217				
Pariyaram	1976	Mullappana	126.560	580.736						
Pariyaram	1977	Mullappana	80.960	403.683						
Vellikulanga	1934	Rv	111.380						1642.452	
Vellikulanga	1937	Rv	21.140						1105.757	
Vellikulanga	1944	Erappanpara	33.390						179.132	
Konni										
Konni	1945	Mundomuzhi	26.900						76.596	
Konni	1947	Nellidappara	9.910						145.908	
Konni	1962	Maramanjakuzhi	41.230					133.141		
Konni	1963	Kalikulam	48.980					249.824		
Konni	1964	Gnallur	41.580				185.853			
Konni	1968	Mundomuzhi	30.000				118.418			
Konni	1970	Avolikuzhi	35.450				41.879			
Konni	1971	Avolikuzhi	19.590		19.089					

Division & Range	Plant Year	Name of Plantation	Area (ha)	Yield in different type of operations (m^3)						
				1M	2M	1S	2S	3S	4S	FF
Konni	1972	Adichenpara	28.000				75.277			
Konni	1972	Avolikuzhi	19.700		95.316		18.803			
Konni	1978	Perumala Bit Ii	35.000		50.470					
Konni	1979	Kummannoor	12.500							
Konni	1982	Maduthamon	14.750			11.545				
Naduvathumoo	1924	Kadiyar	43.302						131.807	
Naduvathumoo	1937	Kokkathode	22.780						267.448	
Naduvathumoo	1938	Kokkathode	32.670						375.292	
Naduvathumoo	1951	Vayakara	40.250					224.277		
Naduvathumoo	1963	Parumthumoozhy	10.620			110.267				
Naduvathumoo	1973	Karipanthode	39.600			121.770				
Naduvathumoo	1973	Karippenthode	41.000			177.752				
Kothamangalam										
Kaliyar	1957	Thenkodam	9.710					55.885		
Mullaringadu	1963	Chathamattam	23.070	50.567				102.773		
Mullaringadu	1965	Chathamattam	66.880	17.549			369.889			
Mullaringadu	1972	Mullaringadu	215.000		81.552					
Mullaringadu	1976	Vellakkayam	79.120		146.368					
Mullaringadu	1977	Chullikkandam	40.570	204.518		231.816				
Mullaringadu	1978	Chullikkandam	121.190			925.982				
Thodupuzha	1982	Thodupuzha	32.360	97.861						
Kottayam										
Erumely	1944	Kalaketty	16.187		79.570	148.725			35.729	
Erumely	1963	Kalaketty	86.800				492.713			
Erumely	1964	Mayapetta	20.200				88.799			
Erumely	1976	Karikattoor	8.390	103.274		100.060				
Erumely	1979	Karikattoor	66.000	464.957						

Division & Range	Plant Year	Name of Plantation	Area (ha)	Yield in different type of operations (m^3)						
				1M	2M	1S	2S	3S	4S	FF
Munnar										
Neriyamangal	1966	Mezhukkumaly	42.960				165.732			
Parambikulam										
Orukomban	1963	Ra Block No:11	75.678					598.690		
Orukomban	1964	Ra Block No:47	47.511					183.198		
Orukomban	1964	Ra Block No:49	44.516					67.810		
Parambikulam	1963	Ra Block No:24	36.584					159.445		
Parambikulam	1963	Ra Block No:25	40.328					196.571		
Parambikulam	1963	Ra Block No:28	45.407					263.137		
Parambikulam	1963	Ra Block No:32	50.789					337.334		
Parambikulam	1963	Ra Block No:36	47.654					304.453		
Parambikulam	1963	Ra Block No:38	34.500					218.462		
Parambikulam	1964	Ra Block No:43	42.938					189.231		
Parambikulam	1964	Ra Block No:65	46.330					572.725		
Punalur										
Anchal	1948	Kadamancode	30.350					86.254	188.295	
Anchal	1950	Kadamancode	39.250					273.122	188.501	
Anchal	1951	Kadamancode	33.660					144.530	88.754	
Anchal	1959	Ayiranellur	18.410				129.666	88.401		
Anchal	1962	Ayiranellur	26.930				66.601	67.850		
Anchal	1963	Ayiranellur	20.280				40.394			
Anchal	1964	Ayiranellur	20.140				46.544			
Anchal	1965	Ayiranellur	21.240				98.497			
Anchal	1967	Urukunnu	27.500		194.692					
Anchal	1968	Urukunnu	40.600		412.207					
Anchal	1973	Ayiranellur	21.700		119.533		154.647			
Anchal	1977	Ayiranellur	99.350		361.583					
Pathanapuram	1977	Karavanthavalam	18.600		67.089					

Division & Range	Plant Year	Name of Plantation	Area (ha)	Yield in different type of operations (m^3)						
				1M	2M	1S	2S	3S	4S	FF
Pathanapuram	1978	Cherippittakavu	78.000		24.908					
Pathanapuram	1981	Karuvanthavalam	35.000			78.835				
Ranni										
Ranni	1968	Rajanpara	9.000				219.730			
Ranni	1983	Kanamala	7.920			25.309				
Ranni	1983	Kudamurutty	16.300			28.668				
Ranni	1983	Pambavally	15.000			105.582				
Ranni	1984	Parahennoore	5.000			10.766				
Vadaserikara	1922	Chengara	39.470					910.479		
Vadaserikara	1924	Chengara	54.900					377.429	406.257	3468.848
Vadaserikara	1937	Chengara	72.070				516.782			
Vadaserikara	1938	Chengara	61.110				205.872			
Vadaserikara	1939	Chengara	50.180						1914.041	
Vadaserikara	1941	Chengara	60.703						427.620	
Vadaserikara	1942	Chengara	60.700		95.843			273.949		
Vadaserikara	1943	Chengara	8.170						40.472	
Vadaserikara	1958	Adukazhy	98.679		235.963					
Vadaserikara	1962	Mamoodupathal	105.906			46.743				
Vadaserikara	1967	Padayanipara	27.390		33.927					
Vadaserikara	1967	Thekkumala	30.554		84.315					
Vadaserikara	1973	Mamoodupathal	42.860				224.033			
Thenmala										
Achencoil	1953	South Series	23.573						128.419	
Aryankavu	1963	Aryankavu	14.760				250.361			
Aryankavu	1968	Aryankavu	34.850				102.621			
Aryankavu	1969	Aryankavu	35.126				248.894			
Aryankavu	1971	Aryankavu	10.240				25.893			
Aryankavu	1972	Aryankavu	9.120				59.841			

Division & Range	Plant Year	Name of Plantation	Area (ha)	Yield in different type of operations (m^3)						
				1M	2M	1S	2S	3S	4S	FF
Aryankavu	1977	Aryankavu	8.000		45.413					
Aryankavu	1978	Aryankavu	43.030		117.348					
Aryankavu	1979	Aryankavu	20.800			172.391				
Aryankavu	1980	Aryankavu	16.972		124.048					
Aryankavu	1980	Kottavasal	27.450		116.540					
Aryankavu	1982	Aryankavu	16.387			139.171				
Aryankavu	1983	Aryankavu	19.160			54.775				
Aryankavu	1985	Aryankavu	29.500	55.255		83.366				
Aryankavu	1985	Edappalayam	37.500			379.624				
Aryankavu	1985	Palaruvi	29.500			229.472				
Kallar	1972	Chittarmoozhy	129.000				1050.628			
Kallar	1973	Chittarmoozhy	81.860				423.406			
Trichur										
Peechi	1928	Pambatty	70.000							4379.938
Vazhachal										
Adirappilly	1961	Vadamuri	49.999				268.165	91.473		
Adirappilly	1964	15 Block	82.720				834.062	911.228		
Adirappilly	1965	15 Block	98.090				279.951			
Adirappilly	1974	Adirappilly	129.550		529.194					
Adirappilly	1977	Adirappilly	156.200		388.911					
Adirappilly	1984	Oliveli	85.156	1029.079						
Charpa	1974	Charpa	117.880			187.612				
Charpa	1979	Karamthode	126.040	70.822						
Charpa	1982	Charpa	40.110	7.082						
Charpa	1988	Charpa	13.760	57.547						
Kollathirime	1973	Repra	115.040		548.307					
Kollathirime	1974	Karadippara	21.100		145.185					

Division & Range	Plant Year	Name of Plantation	Area (ha)	Yield in different type of operations (m^3)						
				1M	2M	1S	2S	3S	4S	FF
Kollathirime	1981	Karadippara	160.280			246.761				
Kollathirime	1981	Repra	160.280	113.314						
Vazhachal	1973	Itumpupalam	72.525		302.424					
Vazhachal	1976	Panjanamkunnu	208.011			692.347				
Vazhachal	1977	Panjanamkunnu	146.318			241.160				
Vazhachal	1982	Itumpupalam	43.100	12.039						
Wynad North										
Begur	1938	Ra Begur	4.050						54.297	
Begur	1943	Shanamangalam	13.360						139.407	
Begur	1950	Tholpetty	31.690					92.389		
Begur	1962	Tholpetty	45.130				485.993			
Begur	1963	Shangamangalm	37.130					180.417		
Begur	1964	Shanamangalam	43.300				156.714			
Begur	1965	Shanamangalam	42.490				347.445			
Begur	1969	Kadirakode	39.000		184.984					
Begur	1973	Kadirakode	43.000			35.967				
Begur	1974	Alathur Rt	6.070			24.229				
Begur	1975	Tholpetty	65.200		437.478	121.105				
Begur	1976	Kadirakode	8.500	14.306						
Begur	1977	Begur	44.660			249.853				
Begur	1977	Begur Cfc I Block Ii	30.000	156.361		254.988				
Begur	1977	Begur Cfc Ii	16.030	38.474						
Begur	1978	Kartikulam	35.350	51.133						
Begur	1978	Kathirakode Cfc Ii	28.960	115.479						
Begur	1978	Ra Tholpetty	10.880	28.076						
Begur	1981	Begur Cfc Iii	64.000	166.381						

Division & Range	Plant Year	Name of Plantation	Area (ha)	Yield in different type of operations (m^3)						
				1M	2M	1S	2S	3S	4S	FF
Wynad South										
Chedalath	1955	Cheeyambam	22.000					159.965		
Chedalath	1959	Pathiri	62.040					394.143		
Chedalath	1969	Pambra	132.000							
Chedalath	1971	Pathiri North	27.360				117.411			
Chedalath	1979	Pathiri North	133.500		289.965	304.969				
Chedalath	1980	Pathiri North	42.000			157.796				
Chedalath	1981	Pathiri North	63.380			327.539				
Chedalath	1982	Pathiri South	21.000			120.277				
Chedalath	1983	Pathiri North	54.450	347.759						
Wynad Wl										
Sulthan Batt	1981		37.500			210.177				
Tholpetty	1943	Tholpetty	34.740						296.676	
Tholpetty	1946	Kaimaram	24.280						289.510	
Tholpetty	1950	Ayyappanpara	18.520						61.552	
Tholpetty	1950	Naikkal	12.950						169.833	
Tholpetty	1952	Ayyappanpara	25.900						383.231	
Tholpetty	1957	Begar	60.000					162.706		
Tholpetty	1966	Kattikulam	43.000				94.397			
Tholpetty	1968	Kattikulam	31.000				26.167			
Tholpetty	1969	Tholpetty	37.000				77.845			
Tholpetty	1973	Begar	12.760		20.824					
Tholpetty	1973	Kudirakode	30.000				80.323			
Tholpetty	1977	Kattikulam	43.660		36.289					
Tholpetty	1978	Kattikulam	13.050		36.976	5.241				
Tholpetty	1978	Tholpetty	10.880		12.890					

Division & Range	Plant Year	Name of Plantation	Area (ha)	Yield in different type of operations (m^3)						
				1M	2M	1S	2S	3S	4S	FF
Tholpetty	1979	Kuthirakode	11.700		27.523					
Tholpetty	1979	Tholpetty	163.900		293.011					
Tholpetty	1981	Kattikulam	60.380			106.742				
Tholpetty	1981	Kuthirakode	39.700			178.190				
Tholpetty	1982	Cfc Iv Kuthirakode	59.060	143.626						
Tholpetty	1982	Kuthirakode	52.620			257.082				

Appendix 2

Division-wise distribution of teak plantations covered

Division	No. of Plantations								Area (ha.)
	1M	2M	1S	2S	3S	4S	FF	Total	
Chalakkudy	4	2	5	8	0	6	0	25	2052.820
Konni	0	4	8	6	8	7	2	35	1035.272
Kothamangalam	4	2	5	6	12	3	4	36	2133.693
Kottayam	2	2	1	2	2	1	0	10	498.341
Munnar	0	0	0	1	0	0	0	1	42.960
Nilambur North	12	19	26	23	36	63	29	208	5703.996
Nilambur South	14	24	31	25	29	23	21	167	6969.876
Parambikulam	0	0	0	0	11	0	0	11	512.235
Punalur	0	1	10	13	10	4	0	38	1425.400
Ranni	0	5	4	7	4	4	4	28	1263.102
Thenmala	2	10	5	18	2	1	14	52	1413.109
Trichur	0	0	0	0	0	0	1	1	70.000
Vazhachal	6	5	7	4	3	0	0	25	2451.173
Wynad North	8	6	2	4	5	6	0	31	1064.920
Wynad South	1	4	3	2	3	0	0	13	925.670
Wynad Wild Life	2	8	13	10	8	16	0	57	2242.025
Total	55	92	120	129	133	134	75	738	29804.592

Appendix 3

List of plantations for which site quality was determined 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	II
1970	Edacode	Teak	46.540	II
1976	Edacode	Teak	50.340	I/II
1978	Edacode	Teak	141.476	I/II
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-Bombax	22.220	II
1967	Kallenthode	Teak	27.410	II
1968	Ezhuthukal	Teak	70.150	I/II
1968	Ingar	Teak-Bombax	20.970	I/II
1968	Kallenthode	Teak	47.190	II
1969	Ezhuthukal	Teak	48.900	I/II
1969	Ingar	Teak-Bombax	18.500	I
1969	Kallenthode	Teak	61.020	II
1969	Poolakkappara	Teak	55.140	I/II
1970	Nedumgayam	Teak	63.440	II
1970	Poolakkappara	Teak	44.300	I/II
1971	Cherupuzha	Teak	70.110	I/II
1971	Ezhuthukal	Teak	52.900	I/II
1971	Ingar	Teak-Bombax	20.550	I/II
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	I/II
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
1975	Ingar	Teak	20.179	I
1975	Mundakadavu	Teak	5.500	II/III
1976	Ezhuthukal	Teak	40.500	I
1976	Ingar	Teak	6.740	I/II
1976	Nedumgayam	Teak	35.812	I
1977	Ezhuthukal	Teak	49.057	I
1977	Ingar	Teak	39.060	I
1977	Nedumgayam	Teak	30.900	I/II
1978	Nedumgayam	Teak	40.550	I/II
1978	Pulimunda	Teak	46.250	I
1979	Ingar	Teak	9.500	I
1979	Ingar	Teak	21.800	I
1979	Sankarancode	Teak	26.300	III
1980	Churulipotty	Teak	19.550	II
1980	Kadannakappu	Teak	96.000	I
Nilambur Range				
1975	Aruvallikavu	Teak	22.370	I/II
1976	Kanakutha	Teak	41.050	I/II
1977	Kanakutha	Teak	16.050	I/II
1978	Aruvallikavu	Teak	1.012	I
1978	Erampadam	Teak	34.780	I/II
1978	Kanakutha	Teak	82.050	I
1979	Kanakutha	Teak	108.230	I/II
1980	Erampadam	Teak	11.000	I/II
1980	Walluvassery	Teak	13.436	I
Vazhikadavu Range				
1972	Kariem Mariem	Teak	49.790	I/II
1973	Kariem Mariem	Softwood	56.880	I/II
1973	Kariem Mariem	Teak	58.750	I/II
1974	Kariem Mariem	Teak	51.430	I/II
1976	Kariem Mariem	Teak	58.750	I
1977	Kariem Mariem	Teak	162.506	I

Source Chundamannil 1997

Appendix 4

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	Slightly	Crooked
I	150-180	>3	and	bend	with
II	100-149	>3	without	without	hollows
III	76-99	>3	any	defects	or nodes
IV	60-75	>3	defects		

Pole class	Girth limits (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 5

Age limits considered for different type of work

Type of work	Nilambur Division					
	1967-81		1982-94		1967-94	
	Min.	Max.	Min.	Max.	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

Type of work	Other Divisions		Kerala	
	1954-95		1954-95	
	Min.	Max.	Min.	Max.
1M	4	7	4	7
2M	8	11	8	11
1S	12	18	12	18
2S	19	27	19	25
3S	28	36	26	34
4S	40	48	35	48
FF	50	72	49	72

Appendix 6

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	16.44	15.68	14.33	12.93	11.23	0.00	0.00
5	17.55	16.67	15.21	13.46	11.41	0.00	0.00
6	18.66	17.67	16.09	13.98	11.58	1.81	1.23
7	19.77	18.66	16.97	14.51	11.76	3.63	2.46
8	20.89	19.66	17.84	15.04	11.93	5.44	3.69
9	22.00	20.65	18.72	15.56	12.11	7.25	4.91
10	23.11	21.65	19.60	16.09	12.29	9.07	6.14
11	23.57	22.00	19.60	16.21	12.34	9.01	6.08
12	24.04	22.35	19.60	16.32	12.40	8.95	6.03
13	24.51	22.70	19.60	16.44	12.46	8.89	5.97
14	24.97	23.05	19.60	16.56	12.52	8.83	5.91
15	25.44	23.40	19.60	16.67	12.58	8.78	5.85
16	26.60	23.99	19.89	16.50	12.40	8.66	5.73
17	27.77	24.57	20.18	16.32	12.23	8.54	5.62
18	28.93	25.16	20.48	16.15	12.05	8.42	5.50
19	30.10	25.74	20.77	15.97	11.88	8.31	5.38
20	31.26	26.33	21.06	15.80	11.70	8.19	5.27
21	31.26	26.38	20.89	15.50	11.58	8.07	5.15
22	31.26	26.44	20.71	15.21	11.47	7.96	5.03
23	31.26	26.50	20.53	14.92	11.35	7.84	4.91
24	31.26	26.56	20.36	14.63	11.23	7.72	4.80
25	31.26	26.62	20.18	14.33	11.12	7.61	4.68
26	29.63	25.21	19.36	13.81	10.88	7.49	4.56
27	28.00	23.81	18.54	13.28	10.65	7.37	4.45
28	26.37	22.41	17.71	12.75	10.41	7.25	4.33
29	24.74	21.00	16.89	12.23	10.18	7.14	4.21
30	23.11	19.60	16.07	11.70	9.95	7.02	4.10
31	22.35	19.07	15.78	11.64	9.65	6.85	3.98
32	21.59	18.55	15.49	11.58	9.36	6.67	3.86
33	20.83	18.02	15.20	11.53	9.07	6.49	3.74
34	20.07	17.49	14.91	11.47	8.78	6.32	3.63
35	19.31	16.97	14.63	11.41	8.48	6.14	3.51
36	18.72	16.50	14.22	11.17	8.37	6.03	3.39
37	18.14	16.03	13.81	10.94	8.25	5.91	3.28
38	17.55	15.56	13.40	10.71	8.13	5.79	3.16
39	16.97	15.09	12.99	10.47	8.02	5.68	3.04
40	16.38	14.63	12.58	10.24	7.90	5.56	2.93
41	15.85	14.16	12.23	10.06	7.78	5.44	2.87
42	15.33	13.69	11.88	9.89	7.66	5.32	2.81
43	14.80	13.22	11.53	9.71	7.55	5.21	2.75
44	14.27	12.75	11.17	9.54	7.43	5.09	2.69
45	13.75	12.29	10.82	9.36	7.31	4.97	2.63

Source : Tewari 1992

Appendix 7

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

Age	Site quality						
	I	I/II	II	II/III	III	III/IV	IV
20	121.97	115.83	98.87	80.15	63.77	47.59	34.52
30	135.43	116.71	102.08	94.19	74.88	57.92	42.12
40	176.67	147.42	120.80	102.08	82.19	65.23	48.56
41	180.71	150.46	123.38	103.19	83.13	66.05	49.08
42	184.74	153.50	125.95	104.31	84.07	66.87	49.61
43	188.78	156.55	128.53	105.42	85.00	67.69	50.14
44	192.82	159.59	131.10	106.53	85.94	68.50	50.66
45	196.85	162.63	133.67	107.64	86.87	69.32	51.19
46	200.83	166.02	136.01	109.16	87.81	70.20	51.95
47	204.81	169.42	138.35	110.68	88.75	71.08	52.71
48	208.79	172.81	140.69	112.20	89.68	71.96	53.47
49	212.77	176.20	143.03	113.72	90.62	72.83	54.23
50	216.74	179.60	145.37	115.25	91.55	73.71	54.99
51	222.00	182.64	147.89	117.14	92.72	74.30	55.81
52	227.25	185.68	150.40	119.03	93.89	74.88	56.63
53	232.50	188.72	152.92	120.92	95.06	75.47	57.45
54	237.75	191.77	155.44	122.81	96.23	76.05	58.27
55	243.00	194.81	157.95	124.70	97.40	76.64	59.09
56	244.25	197.68	160.64	126.90	98.87	77.63	59.85
57	245.49	200.54	163.33	129.11	100.33	78.62	60.61
58	246.73	203.41	166.02	131.31	101.79	79.62	61.37
59	247.98	206.27	168.71	133.52	103.25	80.61	62.13
60	249.22	209.14	171.41	135.72	104.72	81.61	62.89
70	276.12	234.00	193.05	157.95	122.56	93.60	72.83

Source : Tewari 1992

Appendix 8

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

Class of teak poles	Number
I	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	Girth and quality class of teak logs (m^3/ha)												Timber total
		IA	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	0.001	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	10.421	101.083

Type of work	Girth and quality class of poles (m^3/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

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

Type of	Mean	Girth and quality class of teak logs (m^3/ha)												Timber
work	age	IA	IB	IC	IIA	IIB	IIC	IIIA	IIIB	IIIC	IVA	IVB	IVC	total
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	9	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
1S	14	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.001
2S	23	0.000	0.000	0.000	0.000	0.002	0.004	0.000	0.052	0.017	0.000	0.030	0.002	0.108
3S	32	0.000	0.000	0.000	0.000	0.055	0.008	0.000	0.555	0.040	0.000	0.084	0.040	0.781
4S	45	0.000	0.001	0.000	0.000	0.392	0.003	0.000	2.091	0.016	0.000	0.216	0.000	2.718
FF	65	0.000	0.962	0.090	0.000	21.024	0.000	0.000	26.999	0.000	0.000	11.782	0.000	60.856
Total		0.000	0.963	0.090	0.000	21.473	0.015	0.000	29.698	0.073	0.000	12.112	0.042	64.464

Type of	Girth and quality class of poles (m^3/ha)										Pole	Billet	Fire	Total
work	IA	IB	IC	IIA	IIB	IIC	III	IV	V	VI	total		wood	
1M	0.000	0.000	0.000	0.000	0.000	0.000	0.042	1.468	1.689	0.296	3.495	0.000	0.000	3.495
2M	0.000	0.004	0.000	0.000	0.029	0.000	0.351	2.210	1.092	0.030	3.717	0.000	0.000	3.717
1S	0.000	0.022	0.000	0.000	0.086	0.000	0.467	2.655	0.612	0.004	3.846	0.000	0.000	3.846
2S	0.000	0.423	0.000	0.000	0.791	0.000	2.153	2.095	0.199	0.000	5.660	0.004	0.002	5.774
3S	0.000	2.228	0.000	0.000	2.058	0.000	0.909	0.532	0.081	0.000	5.807	0.000	0.016	6.604
FT	0.000	2.432	0.000	0.000	1.673	0.000	1.213	0.293	0.012	0.000	5.623	0.360	4.618	13.319
FF	0.000	1.331	0.000	0.000	4.297	0.000	2.685	0.347	0.000	0.000	8.660	21.773	20.599	111.888
Total	0.000	6.440	0.000	0.000	8.934	0.000	7.820	9.600	3.685	0.330	36.808	22.137	25.235	148.643

Appendix 11

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

Type of work	Mean age	Girth and quality class of teak logs (m^3/ha)												Timber total
		IA	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	9	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
1S	14	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.001
2S	21	0.000	0.000	0.000	0.000	0.002	0.004	0.000	0.049	0.016	0.000	0.028	0.002	0.101
3S	29	0.000	0.000	0.000	0.000	0.087	0.012	0.000	0.867	0.062	0.000	0.131	0.062	1.221
FT	42	0.000	0.001	0.000	0.000	0.425	0.003	0.000	2.267	0.017	0.000	0.234	0.000	2.948
FF	58	0.000	0.874	0.081	0.000	19.093	0.000	0.000	24.519	0.000	0.000	10.700	0.000	55.267
Total		0.000	0.875	0.081	0.000	19.607	0.019	0.000	27.703	0.095	0.000	11.093	0.064	59.538

Type of work	Girth and quality class of poles (m^3/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	0.047	1.651	1.899	0.333	3.931	0.000	0.000	3.931
2M	0.000	0.005	0.000	0.000	0.037	0.000	0.444	2.796	1.382	0.038	4.702	0.000	0.000	4.702
1S	0.000	0.025	0.000	0.000	0.099	0.000	0.537	3.056	0.705	0.004	4.426	0.000	0.000	4.427
2S	0.000	0.395	0.000	0.000	0.739	0.000	2.013	1.959	0.186	0.000	5.294	0.004	0.002	5.401
3S	0.000	3.480	0.000	0.000	3.215	0.000	1.420	0.832	0.126	0.000	9.073	0.000	0.025	10.318
FT	0.000	2.637	0.000	0.000	1.814	0.000	1.316	0.318	0.013	0.000	6.097	0.390	5.007	14.442
FF	0.000	1.209	0.000	0.000	3.902	0.000	2.439	0.315	0.000	0.000	7.865	19.774	18.707	101.612
Total	0.000	7.751	0.000	0.000	9.806	0.000	8.216	10.927	4.311	0.375	41.388	20.168	23.741	144.833

Appendix : 12

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 (m^3/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 (m^3/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 : 13

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

Type of work	Mean age	Girth and quality class of teak logs (m^3/ha)												Timber total
		IA	IB	IC	IIA	IIB	IIC	IIIA	IIIB	IIIC	IVA	IVB	IVC	
1M	6	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	9	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
1S	14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.02
2S	23	0.00	0.00	0.00	0.00	0.04	0.07	0.00	0.90	0.30	0.00	0.52	0.04	1.87
3S	32	0.00	0.00	0.00	0.00	0.84	0.12	0.00	8.40	0.60	0.00	1.27	0.60	11.83
FT	45	0.00	0.01	0.00	0.00	2.94	0.02	0.00	15.70	0.12	0.00	1.62	0.00	20.41
FF	65	0.00	0.86	0.08	0.00	18.79	0.00	0.00	24.13	0.00	0.00	10.53	0.00	54.39

Type of work	Girth and quality class of poles (m^3/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	1.20	42.01	48.31	8.48	100.00	0.00	0.00	100.00
2M	0.00	0.10	0.00	0.00	0.79	0.00	9.44	59.47	29.39	0.81	100.00	0.00	0.00	100.00
1S	0.00	0.57	0.00	0.00	2.24	0.00	12.13	69.02	15.92	0.10	99.98	0.00	0.00	100.00
2S	0.00	7.32	0.00	0.00	13.69	0.00	37.28	36.28	3.45	0.00	98.02	0.07	0.04	100.00
3S	0.00	33.73	0.00	0.00	31.16	0.00	13.76	8.06	1.22	0.00	87.93	0.00	0.24	100.00
FT	0.00	18.26	0.00	0.00	12.56	0.00	9.11	2.20	0.09	0.00	42.22	2.70	34.67	100.00
FF	0.00	1.19	0.00	0.00	3.84	0.00	2.40	0.31	0.00	0.00	7.74	19.46	18.41	100.00

Appendix 14

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	3991.96
	7	358.00	0.00	-358.00
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 15

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

Appendix 16

Cashflow from teak plantations in Other 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	505.23	1306.47	801.24
	7	358.00	0.00	-358.00
	8	358.00	0.00	-358.00
2 Mech. thinning	9	728.18	5810.32	5082.15
Tending	10	2628.00	0.00	-2628.00
	11	358.00	0.00	-358.00
	12	358.00	0.00	-358.00
	13	358.00	0.00	-358.00
1 Silvi. thinning	14	522.35	3119.29	2596.94
	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
	19	358.00	0.00	-358.00
	20	358.00	0.00	-358.00
	21	358.00	0.00	-358.00
	22	358.00	0.00	-358.00
2 Silvi. thinning	23	918.87	8020.12	7101.25
	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
	28	358.00	0.00	-358.00
	29	358.00	0.00	-358.00
	30	358.00	0.00	-358.00
	31	358.00	0.00	-358.00
3 Silvi. thinning	32	1318.41	19729.08	18410.67
Loranthus cutting	33	1093.00	0.00	-1093.00

Type of work	Age (Yr.)	Cost (Rs.)	Benefit (Rs.)	Net benefit (Rs.)
	34	358.00	0.00	-358.00
Climber cutting	35	462.00	0.00	-462.00
	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
	41	358.00	0.00	-358.00
	42	358.00	0.00	-358.00
	43	358.00	0.00	-358.00
	44	358.00	0.00	-358.00
4 Silvi. thinning	45	3976.28	33561.20	29584.92
Loranthus cutting	46	717.00	0.00	-717.00
	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
	53	358.00	0.00	-358.00
	54	358.00	0.00	-358.00
	55	358.00	0.00	-358.00
	56	358.00	0.00	-358.00
	57	358.00	0.00	-358.00
	58	358.00	0.00	-358.00
	59	358.00	0.00	-358.00
	60	358.00	0.00	-358.00
	61	358.00	0.00	-358.00
	62	358.00	0.00	-358.00
	63	358.00	0.00	-358.00
	64	358.00	0.00	-358.00
Final felling	65	19129.85	864299.20	845169.35
Total		66016.17	935845.68	869829.52

Appendix 17

Cashflow from teak plantations in Other 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	6712.00	56395.58	49683.58
	7	358.00	0.00	-358.00
	8	358.00	0.00	-358.00
2 Mech. thinning	9	4314.63	62095.85	57781.22
Tending	10	2628.00	0.00	-2628.00
	11	358.00	0.00	-358.00
	12	358.00	0.00	-358.00
	13	358.00	0.00	-358.00
1 Silvi. thinning	14	5797.57	103239.93	97442.36
	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
	19	358.00	0.00	-358.00
	20	358.00	0.00	-358.00
	21	358.00	0.00	-358.00
	22	358.00	0.00	-358.00
2 Silvi. thinning	23	9554.63	131388.44	121833.81
	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
	28	358.00	0.00	-358.00
	29	358.00	0.00	-358.00
	30	358.00	0.00	-358.00
	31	358.00	0.00	-358.00
3 Silvi. thinning	32	9996.44	197934.26	187937.82
Loranthus cutting	33	1093.00	0.00	-1093.00

Type of work	Age (Yr.)	Cost (Rs.)	Benefit (Rs.)	Net benefit (Rs.)
	34	358.00	0.00	-358.00
Climber cutting	35	462.00	0.00	-462.00
	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
	41	358.00	0.00	-358.00
	42	358.00	0.00	-358.00
	43	358.00	0.00	-358.00
	44	358.00	0.00	-358.00
4 Silvi. thinning	45	39128.35	359587.63	320459.28
Loranthus cutting	46	717.00	0.00	-717.00
	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
	53	358.00	0.00	-358.00
	54	358.00	0.00	-358.00
	55	358.00	0.00	-358.00
	56	358.00	0.00	-358.00
	57	358.00	0.00	-358.00
	58	358.00	0.00	-358.00
	59	358.00	0.00	-358.00
	60	358.00	0.00	-358.00
	61	358.00	0.00	-358.00
	62	358.00	0.00	-358.00
	63	358.00	0.00	-358.00
	64	358.00	0.00	-358.00
Final felling	65	68696.31	3146431.61	3077735.30
Total		183116.93	4057073.30	3873956.37

Appendix 18

Cashflow from teak plantations in Kerala 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	574.91	1918.41	1343.50
	7	358.00	0.00	-358.00
	8	358.00	0.00	-358.00
2 Mech. thinning	9	862.46	7915.19	7052.73
Tending	10	2628.00	0.00	-2628.00
	11	358.00	0.00	-358.00
	12	358.00	0.00	-358.00
	13	358.00	0.00	-358.00
1 Silvi. thinning	14	523.99	3145.07	2621.08
	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
	19	358.00	0.00	-358.00
	20	358.00	0.00	-358.00
2 Silvi. thinning	21	539.21	2587.61	2048.40
	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
	28	358.00	0.00	-358.00
3 Silvi. thinning	29	1526.98	24024.04	22497.06
	30	358.00	0.00	-358.00
	31	358.00	0.00	-358.00
	32	358.00	0.00	-358.00
Loranthus cutting	33	1093.00	0.00	-1093.00

Type of work	Age (Yr.)	Cost (Rs.)	Benefit (Rs.)	Net benefit (Rs.)
	34	358.00	0.00	-358.00
Climbing	35	462.00	0.00	-462.00
	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
	41	358.00	0.00	-358.00
4 Silvi. thinning	42	4502.29	38430.05	33927.76
	43	358.00	0.00	-358.00
	44	358.00	0.00	-358.00
	45	358.00	0.00	-358.00
Loranthus cutting	46	717.00	0.00	-717.00
	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
	53	358.00	0.00	-358.00
	54	358.00	0.00	-358.00
	55	358.00	0.00	-358.00
	56	358.00	0.00	-358.00
	57	358.00	0.00	-358.00
Final felling	58	14685.63	659674.36	644988.73
Total		59626.48	737694.73	678068.26

Appendix 19

Cashflow from teak plantations in Kerala 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	6777.44	56969.67	50192.23
	7	358.00	0.00	-358.00
	8	358.00	0.00	-358.00
2 Mech. thinning	9	4826.16	70112.08	65285.92
Tending	10	2628.00	0.00	-2628.00
	11	358.00	0.00	-358.00
	12	358.00	0.00	-358.00
	13	358.00	0.00	-358.00
1 Silvi. thinning	14	5127.46	90517.12	85389.66
	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
	19	358.00	0.00	-358.00
	20	358.00	0.00	-358.00
2 Silvi. thinning	21	9013.54	123628.55	114615.01
	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
	28	358.00	0.00	-358.00
3 Silvi. thinning	29	13559.27	271087.23	257527.96
	30	358.00	0.00	-358.00
	31	358.00	0.00	-358.00
	32	358.00	0.00	-358.00
Loranthus cutting	33	1093.00	0.00	-1093.00

Type of work	Age (Yr.)	Cost (Rs.)	Benefit (Rs.)	Net benefit (Rs.)
	34	358.00	0.00	-358.00
Climbing	35	462.00	0.00	-462.00
	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
	41	358.00	0.00	-358.00
4 Silvi. thinning	42	36738.48	337399.06	300660.59
	43	358.00	0.00	-358.00
	44	358.00	0.00	-358.00
	45	358.00	0.00	-358.00
Loranthus cutting	46	717.00	0.00	-717.00
	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
	53	358.00	0.00	-358.00
	54	358.00	0.00	-358.00
	55	358.00	0.00	-358.00
	56	358.00	0.00	-358.00
	57	358.00	0.00	-358.00
Final felling	58	67191.57	3077183.25	3009991.69
Total		179644.91	4026896.96	3847252.06