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ECONOMICS OF FOREST PLANTATIONS IN KERALA

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ABSTRACT

The study examined the productivity and profitability of different forest plantations in Kerala. As no information was readily available, the strategy adopted was to collect information on yield from regular forestry operations. The average productivity, the variability in yield and the mean of the best and the poorest 10% of the plantations is presented.

Forest plantations are managed in different rotations and there are differences in the felling cycles for the same species in different regions. Teak plantation managed on a mean rotation of 58 years had mean annual increment (MAI) of 2.516 m^3 $ha^{-1}year^{-1}$. The MAI of eucalypt plantations was found to be 6.432 MT $ha^{-1}year^{-1}$ in an 8 year rotation and pine 3.60 MT $ha^{-1}year^{-1}$ on a 23 year rotation.

To compare the profitability of different plantations with different rotation age, the net present value (NPV) at infinity was computed. Except for teak, which had a positive NPV, all other plantations showed a negative NPV even at 6% rate of discounting. When land cost or rent was not considered the internal rate of return (IRR) of teak plantations was 25.9% and that of eucalypts was found to be –4%. The maximum surplus or land rent that is possible at current levels of productivity and prices has been estimated as Rs. 2750 $ha^{-1}year^{-1}$ at 12% rate of discounting for teak. For other plantations there was no surplus and the annual loss was Rs. 2800 $ha^{-1}year^{-1}$ for eucalypts at 12% rate of discounting and Rs. 3000 $ha^{-1}year^{-1}$ for silver oak.

On financial grounds there is no justification to continue with plantations other than teak. As the National Forest Policy does not endorse subsidising forest raw materials to industries the pricing strategy should aim at securing reasonable returns, at least covering the cost of production, if not the opportunity cost of the land. A minimum price for pulpwood has been worked out which is Rs. 2000 MT^{-1} at 12% rate of discounting for eucalypts, Rs. 2925 for wattle and Rs. 3000 MT^{-1} for Acacia when a land rent of Rs.2500 ha^{-1} is considered. Whether the subsidised supply of forest raw materials to industries should continue and for how long is a matter for the government to decide. This study indicates the magnitude of such subsidies.

1. INTRODUCTION

In the history of forest plantations in India, Kerala has a pioneering place due to the Nilambur Teak plantations initiated in 1844. Even today, teak (*Tectona grandis*) continues to be the principal species in forest plantations of Kerala and occupies nearly half of the total area under forest plantations (Chundamannil 1993). Eucalypt plantations (*Eucalyptus teriticornis* and *E. grandis*), initiated to afforest grass lands, were expanded on a large scale to meet the pulpwood raw material needs of Hindustan Newsprint Ltd in the public sector and Grasim Industries in the private sector. Bombax was introduced to supply matchwood to the small scale industries as a scheme under the National Five-Year Plan with central assistance. Bombax plantations (*Bombax cieba*), were usually raised as mixed plantations with teak and periodic thinning may have favoured teak in the crop composition. These plantations are just getting mature for felling. *Acacia auriculiformis* was propagated on a large scale by the World Bank aided Social Forestry Project as a fuel wood tree. But it eventually finds its way to the pulp factories. Species like albizia (*Paraserianthes falcataria*), pine (*Pinus spp*), silver oak (*Grevillea robusta*), and wattle (*Acacia mearnsii*) plantations have been introduced on an experimental basis as part of national level field trials coordinated by the Forest Research Institute or at the individual initiative of officers. These plantations have not expanded beyond their initial areas.

Raising plantations is an important development programme of the Forest Department. Like most government departments, development projects are not critically screened for economic efficiency for long periods. Lack of information on the performance of different plantations raised in the forests of Kerala has hampered a realistic economic assessment of the programme. This study was initiated with the following objectives:

(i) to estimate the productivity of forest plantations in Kerala based on actual yields.
(ii) to analyze the profitability of forest plantations and
(iii) to compare the performance of different plantations and discuss the options in management.

The scheme of the report is as follows: The methodology used in the study is described in section 2. The results of the productivity and profitability of teak, eucalypts, acacia, albizia, bombax, pine, silver oak, and wattle plantations are presented in section 3. The comparative

economics of the different plantations is discussed in section 4 and in section 5 the conclusions of the study are presented.

2. METHODOLOGY

This section deals with the database, the methodology adopted for estimating the productivity and analysing the profitability of forest plantations in Kerala.

2.1 Database

The data required for this study has been collected from unpublished records, registers and files of the Kerala Forest Department and to a limited extent from that of the Kerala Forest Development Corporation. The basic information collected from Range Offices are the name, year of plantation, area and yield from the final harvest or in intermediate thinnings or coppicing. Only plantations where yield data was available were considered and those currently standing and from which no yield data was available were excluded. The data set contains the actual yields that were obtained. The data set of these plantations were obtained from different Range Offices where felling had taken place. In fact, the entire data set available was used, and the basis of analysis was the mean yield per hectare. For teak and eucalypt plantations, the data set was quite large compared to the existing plantations. So the mean yields are representative. For silver oak and bombax, however, the coverage was very small. Yet they are included to give an indication of their performance about which no information is so far reported.

2.2 Productivity

Conventionally, productivity of plantations is analysed based on the Mean Annual Increment (MAI), which is the yield per hectare per year. This facilitates a comparison of plantations with different rotation age. The yields obtained from each plantation were converted into per hectare terms by dividing it with the area of plantation. For each species of plantations, the weighted average yield per ha was worked out considering the area of each plantation as the weight. As the maximum and minimum may be an unusual occurrence, the yields corresponding to the highest decile and the lowest decile have also been calculated to represent the best and the poor plantations. The maximum and minimum yields represent extreme values. 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 are shown as high and low yields respectively.

Teak plantations are managed on a rotation of 50 years in Nilambur, 60 years in most other divisions and 70 years in Konni and some other divisions. From the yield data that was available, the mean age of final felling was worked out as 58 years and this is used for the analysis. Six intermediate thinnings are carried out before the final felling. The first 2 thinnings are called 'mechanical' thinnings and the subsequent 4 'silvicultural'. In the yield data presented, the thinning are denoted as IM, 2M, 1S to 4S indicating the different thinnings. The mean age of operation observed from the yield data is shown as the mean age of different thinning operations.

The data set, that was used, contains yield from different plantations and different operations (See appendix 1 for division-wise distribution of teak plantations covered). Only in a very few cases have successive thinnings yields from the same plantations have been obtained. In the yield data that is presented, the total area indicates the sum of the area from which the yield information was collected. For example, if three thinning yields are obtained from a single plantation the total area shown is thrice the actual area of the plantation. Even for final felling, two successive fellings will have the area doubled. This caution must be used while interpreting the area coverage of this study as it may appear that the area from where the yield data was collected is larger than the area of the existing plantations.

For analysing the productivity of eucalypts, it is necessary to know the age at felling of each plantation. There is a problem to find out the specific age of each coppice. What are definitely known are the year of initial planting and the year of some coppice felling. When the year of the previous coppice is not known it would appear that the age is much longer, often double or triple that of the actual coppice age. There are also several instances where felling was delayed.

Eucalypt plantations were initially managed on a ten year rotation which was changed to an 8 year rotation in the eighties and to a 6 year rotation in the early nineties. Among the initial plantations some areas reserved for the Hindustan Newsprint Limited continued unfelled for more than 20 years as there was delay in the start up of the plant. But this situation affected only a small number of plantations from which data was obtained. Precise age of coppice could be obtained for only a

small number of plantations. It was considered prudent to use the entire set of yield data available even when the actual age of coppice is not known by taking the average age as 8 years. The fact that some plantations had a coppice rotation of 10 years and others of 6 years were considered to neutralise each other and an average age of 8 years may not distort the yield picture. As the mean yields obtained per hectare is shown along with the yields conforming to the highest and lowest deciles, performance of the best and the poor plantations can also be judged.

The yield data of eucalypts collected covers 571 plantations involving an area of 39083.93 ha. Appendix 7 shows the division wise distribution of plantations from which yield data was used in this study. Despite of the ambiguity regarding the age of coppice crop, the mean yield has been worked out taking 8 years as the coppice age, for analysis purposes.

There is an element of ambiguity or haziness in the volume of yield and the weight of eucalypts sold to the pulp mills. Conversion of stacked volume to weight and correction for moisture content after weighing at the factory gate, drying of eucalypt wood in the temporary stock yards of the companies all complicate the determination of the production of each plantation. The situation is confounded when factory records club the arrival and payments contractor-wise when the same contractor harvests different plantations simultaneously.

For other species, the mean age of felling has been considered. As in the case of teak and eucalypts, the age of harvest may not conform to that prescribed in the Working Plans. Division wise distribution of distribution of Acacia, Albizia, Bombax, Silver oak, Pine and Wattle plantations from which yield data was used and their area is shown in Appendix 9. The mean yield per hectare and the yield corresponding to the lowest and highest deciles have been calculated for each species.

2.3 Profitability

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 profitability analysis was based on the prices obtained by the department. Some of these prices are administered prices declared by the Government during the period under review and some prices obtained in public auctions. Here again the difference between teak and other species is important. While teak is converted into logs, dressed and brought to the depots which have good road access, the other plantations when auctioned are sold standing. This means that the purchaser has to arrange for the felling, conversion and transportation from interior areas. Further when plantations are sold enblock the end users cannot participate in the auction due to the large quantity available and the logistical problems. While teak is sold in smaller lots of 4 m^3 or less many end users can also participate in the auctions along with the traders. In the case of other species the price obtained will necessarily be low as these species are neither in high demand nor is there a great competition among the bidders.

The intention of the study is to show the actual performance of forest plantations both in productivity and financial terms. When administered prices are the reality for some species the financial performance reflect the level of prices. Appendix 10 and 11 show the price of plantation wood used in the profitability analysis.

For Eucalypts and other species, as no thinnings are carried out, no intermediate yields are available. The revenue is calculated by multiplying the coppice or final yield with the price per unit.

To prepare the cash flow tables with real prices for cost-benefit analysis usually historic costs are converted into current prices by using an appropriate price index. As the available price indices are unrelated to the movement of cost of raising forest plantations in Kerala, the actual average cost of different operations for the year 1995 was used in this analysis. For most of the operations the per ha cost was estimated as the average actual cost obtained from different ranges (ordinary, difficult and very difficult). For operations such as thinning and harvesting, the costs are based on the yields obtained. For example, the cost of felling will vary with the quantity of output. The cash flow tables of different species were prepared taking the average cost of operations in selected ranges during the year 1995.

While teakwood is sold in regular open auctions, many other plantation outputs are allotted to selected industrial units at a price fixed by negotiations or by a unilateral declaration by the government taking into consideration the cost of production, past years price, open market price etc. This study shows the profitability of different species at the prices currently fixed by the government as well as the price level necessary to secure a profitability of 6, 9, 12 or 18% at the current level of productivity.

The average cost per ha for different operations (from nursery raising to final felling) was compiled from the cost data from different forest ranges. 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 from teak 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 required. The break up of yield obtained from the plantation journals, files and other records was converted into per hectare terms for each operation. The percentage distribution was used for distributing the mean yields into different items of poles and timber in different operations. The mean distribution was then worked out for each operation.

The weighted 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. Appendix 5 shows the price of different classes of teak logs and poles used in the analysis. 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 profitability analysis was carried out following the procedure given in Gregersen and Contreras (1992). From the stream of costs and returns, cash flow tables were prepared for mean, low and high yields. Net present value (NPV) was computed using the formula

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

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

Internal Rate of Return 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.

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 plantations.

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 cost for land has been considered. Similar studies have also avoided valuation of opportunity costs of replacing natural forests with plantation (for e.g. see Nair, 1977). Although all forest plantations, except a small area in the grasslands, were raised after clear felling natural forests, since 1980 Forest Conservation Act, natural forests are not cleared for raising new plantations. Only replanting or augmentation planting in the existing plantation sites is carried out. Therefore it is not relevant to consider the opportunity costs of replacing natural forests with plantations. What could be considered is a land rent for the area occupied by the plantations. It is difficult to prescribe an appropriate rent for Reserve Forest land. In this circumstance, the profitability analysis has been carried out without land rent and with two levels of land rent viz. Rs.1300 ha^{-1} and Rs.2500 ha^{-1}. Currently the Forest Department charges a rent of Rs.1300 ha^{-1} for lands leased to Public Sector Corporations such as Plantation Corporation of Kerala for raising rubber plantations. A revision is long overdue.

2.4 Comparison of profitability

Net present value of different species with different rotations cannot be readily compared. For facilitating comparison, Net Present Value at infinity is computed. This eliminates the effect of rotation age by considering successive rotations to infinity. While plantations like teak are raised from seedlings in successive rotations, eucalypts is coppiced for 2 or 3 rotations before being replanted. The cost of raising a seedling crop and a coppice crop is different. However in the case of eucalypts the full initial cost is considered in successive rotations to find the NPV at infinity. One reason for this is the need for augmentation planting and special site improvement measures in coppiced areas as coppice vigour and density is often very poor in successive rotations in Kerala.

Another approach has also been taken to see what land rent or surplus is obtainable given the current productivity level and prices. In this study the opportunity cost of land is not considered basically because no natural forests are being converted to plantations and only the existing plantations are maintained. The forest department charges a land rent to public sector corporations which have leased in reserved forests for plantation activities. The land rent was fixed long back and they do not reflect the current market rent. Instead of considering an arbitrary land rent, as an alternative the question was posed this way "what is the land rent or surplus that is available given the current

level of productivity and prices?" The annual surplus that is available is considered as the maximum land rent possible given this level of inputs and management. This information is presented as the maximum surplus that is available.

3. PRODUCTIVITY AND PROFITABILITY OF FOREST PLANTATIONS

TEAK

Teak is the traditional species of forest plantation pioneered in Kerala. Teak plantations have a fairly unbroken record of annual expansion till the late 1980s. The technique of raising teak plantations have been perfected in the forest of Kerala. In this section, productivity of teak plantations in the government forests of Kerala based on actual yields is analysed.

3.1.1 Productivity

Although teak is a long rotation crop, due to intermediate thinning it has the advantages of a short rotation crop. The mean, maximum and minimum yields obtained have been estimated. The minimum and maximum are extreme values, which are not used for further analysis. For financial analysis, 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. The estimated MAI in the lowest decile is 0. 788 $m^3ha^{-1}yr^{-1}$ and that in the highest decile is 5.445 $m^3ha^{-1}yr^{-1}$. The MAI in the highest decile can be considered as the potential productivity in good sites.

The expected final felling yields and MAI for 58 years have been interpolated and given in Table 1. The yields expected in thinning and final felling for the mean age of different operations in different site quality classes are shown in Appendices 2 and 3 respectively.

Table 1
Total yield and MAI at 58 years for different site quality classes

Age	Item	Yield in different site quality classes (m^3ha^{-1})						
		I	I/II	II	II/III	III	III/IV	IV
58	Total yield	552.16	475.6	396.7	318.4	245.3	174.5	119.5

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

The productivity in Nilambur North and South Divisions which follows a rotation of 50 years has been published in the study `Teak plantations in Nilambur: an economic review' (Chundamannil 1998). All the other Divisions, excluding Nilambur, follow a rotation of 60 or 70 years.

An earlier survey by the Kerala Forest Research Institute on yield from teak plantations in four major teak growing Forest Divisions in Kerala 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 $m^3ha^{-1}year^{-1}$ (KFRI 1979). Table 3 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.

The data from Nilambur Divisions and Other Divisions were pooled together to cover the entire state and the productivity status is presented in Table 2. Data from 717 plantations covering 28,802 ha were used for the analysis. The mean rotation age is 58 years and the total yield is 145.947 m^3ha^{-1} The MAI at 58 years is 2.516 m^{-1} $ha^{-1}yr^{-1}$. The high variability in the yields can be seen from the minimum and maximum total yields which are 31 and 401 m^3 ha^{-1} respectively. The mean total yield in the lowest decile is 45.713 m^3ha^{-1} and that in the highest decile is 315.788 m^3ha^{-1}. Table 3 shows the average yield of the teak plantations in Kerala and the site quality assessed based on actual

yield. Considering the mean total yield, the site quality observed is IV. Even for the plantations with yield in the highest decile, the site quality attained is only II/III.

Table 2
Average yield from teak plantations in Kerala obtained during the period 1954 to 1995

Type of work	Mean age	No of Pltn.	Total area (ha)	Yield (m^3 ha^{-1})			
				Min	Max	Mean	CV(%)
1M	6	55	2334.321	0.177	12.309	3.931	78.0
2M	9	92	4406.370	0.402	14.801	4.702	61.3
1S	14	128	6153.927	0.215	17.911	4.360	75.0
2S	21	102	5134.252	0.110	36.114	5.301	91.8
3S	30	127	4873.874	1.522	35.749	9.947	81.2
FT	42	140	3905.253	2.207	51.174	14.770	59.7
FF	58	73	1994.021	28.623	232.420	102.936	47.8
Total		717	28802.018	31.138	401.887	145.947	
MAI at 58 Years (m^3 $ha^{-1}year^{-1}$)				0.537	6.929	2.516	

Table: 3
Average yield of teak plantations and site quality observed in Kerala

Type of work	Mean		Lowest decile		Highest decile	
	Yield (m^3 ha^{-1})	Site Quality	Yield (m^3 ha^{-1})	Site Quality	Yield (m^3 ha^{-1})	Site Quality
1M	3.931	III/IV	0.358	Failure	10.595	III/IV
2M	4.702	Failure	1.142	Failure	10.115	III/IV
1S	4.360	Failure	0.394	Failure	11.506	III/IV
2S	5.301	IV	0.317	Failure	13.400	III
3S	9.947	III/IV	1.756	Failure	23.788	I
FT	14.770	I/II	3.964	IV	36.380	I
FF	102.936	III	37.782	Failure	210.004	I/II
Cumulative Yield	145.947	IV	45.713	Failure	315.788	II/III
MAI	2.516	IV	0.788	Failure	5.445	II/III

A more alarming feature is the indication of site deterioration between and within rotations (Chacko 1998, Chundamannil 1998). This has

serious implications on future yields. Overall it clearly indicates that there is considerable scope and need for improving the productivity of teak plantations in Kerala (Chundamannil 2000). The Indian situation is no different (Subramoniam *et al* 2000).

3.1.2 Profitability

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.

Cost include expenditure on planting, maintenance, thinning and final felling in different years. 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 cost and mean yield obtained in each operation in selected plantations. The mean costs per m^3 were 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.

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 percentage distribution of yield from teak plantation in different type of work is presented in Appendix 4.

The output from a teak plantation is 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.

The average price of teak for different girth and quality classes during 1995 is given in Appendix 5. Teak logs and poles are classified according to girth and quality classes. The prices given 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. KFRI (1979) 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.

Appendix 6 shows the cash flow from teak plantations in Kerala with mean yield. 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 4 show the NPV and B/C ratio at different discount rates and IRR. This table shows the profitability 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, the NPV for mean yield is Rs. 24,000. For high yield it is Rs. 79,000 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 25.9%.

Considering a land rent of Rs. 1300 ha^{-1} the IRR reduces to 17.1%. When a land rent of Rs. 2500 ha^{-1} is considered the IRR becomes 12.2%. The NPV at 12% rate of discount for plantations with mean yield reduces from Rs. 24,000 without land rent to Rs. 12,000 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 4
NPV and B/C ratio at different discount rates and IRR of teak plantations in Kerala

Land Rent (Rs ha^{-1} $year^{-1}$)	Yield Level	Discount rate								IRR (%)
		6%		9%		12%		18%		
		NPV	BCR	NPV	BCR	NPV	BCR	NPV	BCR	
0	0.788	14	1.7	-4	0.8	-8	0.4	-9	0.3	7.9
	2.516	121	5.5	48	3.4	24	2.4	7	1.5	25.9
	5.445	304	9.1	137	6.1	79	4.7	36	3.2	45.2
1300	0.788	-8	0.8	-20	0.4	-20	0.2	-18	0.2	5.3
	2.516	99	3.0	32	1.9	12	1.4	-1	1.0	17.1
	5.445	282	5.7	122	3.9	67	3.0	27	2.1	35.3

	0.788	-29	0.5	-34	0.3	-31	0.2	-25	0.1	3.9
2500	2.516	78	2.1	18	1.4	1	1.0	-9	0.7	12.2
	5.445	261	4.2	107	2.9	55	2.2	19	1.6	28.7

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

3. 2 EUCALYPTS

Next to teak, eucalypts occupy the largest area under forest plantations in Kerala. Eucalypts is currently managed on a rotation of six years. Earlier ten and eight-year rotations were adopted. Regeneration is by coppice growth and augmented wherever necessary by replanting. The entire production of eucalypt wood is allotted to the pulp factories in Kerala to meet the contractual obligation of the government with the units (see Krishnankutty and Chundamannil 1985, Chundamannil 1990). Many areas initially planted with *E. Grandis* have been converted to *E. teriticornis* subsequently following failures due to poor site matching or disease (Nair 1986). In fact it was quite difficult to distinguish between *E. grandis* and *E. teriticornis* in the yield data available from the different forest offices and the mills. For all practical purposes, the forest department considers all eucalypt species together as "softwood" (inaccurately to refer to its use as pulpwood) and the price is the same irrespective of the species. Therefore in this study too, no distinction is made between the different species of eucalypts.

3.2.1 Productivity

Based on the yield data from 571 plantations (see Appendix 7) covering an area of 39083 ha, the mean yield per hectare has been estimated as 51.4 MT ha^{-1}. The MAI has been calculated taking 8 years as the rotation age. The MAI thus worked out from the entire data works out to 6.432 MT ha^{-1}. There is high variability in the yield as can be seen from the yield range given in Table 5. For the profitability analysis the yields corresponding to the lowest and highest deciles are also used and henceforth they are referred to as low and high yield respectively.

Table: 5

Productivity of Eucalypt Plantations in Kerala

Rotation age	No. of Plantation	Total Area (ha.)	Yield (MT ha^{-1})			MAI MT ha^{-1} $year^{1}$
			Mean	Lowest decile	Highest decile	
8	571	39083.930	51.456	2.919	180.296	6.432

3.2.2 Profitability

The productivity and the price at which the produce is sold influence profitability. As eucalypt wood is sold to the pulp mills at a predetermined price fixed by the government from year to year, the choice of the price is crucial in determining the profitability. For analysis the price considered is Rs.487 MT^{-1}. This reflects the price fixed by the government. Appendix 8 shows the cash flow of low, mean and high yield from eucalypt plantations in Kerala with a coppice rotation of 8 years.

The cash flow has been worked out with the same stream of average costs per ha for 8-year rotation. On the revenue side as no taungya or thinning is considered, the yield is multiplied with the prices considered. The Internal Rate of Return (IRR), Net Present Value (NPV) and Benefit Cost Ratio (BCR) of eucalypt plantations are calculated and shown in Table 6 for mean, low and high yield without land rent and two land rent regimes, Rs.1300 and Rs.2500 per hectare respectively.

Even when no land rent is considered, with a price of Rs. 487 MT^{-1}, the profitability is negative by any criteria. If the yield in the highest decile is considered, the IRR becomes 17 percent. The NPV at 12% discount rate becomes Rs. 9,000 ha^{-1} and Benefit Cost Ratio becomes 1.3. The implication of a land rent of Rs. 1,300 ha^{-1} and Rs. 2,500 ha^{-1} on the IRR, NPV and BCR with the same price of Rs.487MT^{-1} is given in Table 6. As can be expected the profitability declines further.

Table: 6
NPV and B/C ratio at different discount rates and IRR of Eucalypt plantations in Kerala with coppice age 8 years

Land Rent Rs.	Yield Level	Discount rate								IRR (%)
		6%		9%		12%		18%		
		NPV	BCR	NPV	BCR	NPV	BCR	NPV	BCR	
Nil	Low	-28	0.0	-27	0.0	-26	0.0	-24	0.0	-67.09
	Mean	-13	0.5	-15	0.5	-16	0.4	-18	0.3	-4.10
	High	26	1.9	17	1.6	9	1.3	-1	1.0	17.32
1300	Low	-37	0.0	-35	0.0	-33	0.0	-30	0.0	-149.34
	Mean	-23	0.4	-23	0.3	-24	0.3	-24	0.2	-10.23
	High	17	1.4	8	1.2	1	1.0	-8	0.8	12.76
2500	Low	-46	0.0	-43	0.0	-41	0.0	-37	0.0	-169.78
	Mean	-31	0.3	-31	0.3	-31	0.2	-30	0.2	-15.42
	High	8	1.2	0	1.0	-6	0.9	-14	0.6	9.10

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

From the analysis it can be seen that either the productivity or the price has to go up for eucalypt plantations to be profitable.

3. 3 OTHER SPECIES

Apart from teak and eucalypts, the productivity and profitability of acacia (*Acacia auriculiformis*), albizia (*Paraserianthes falcataria*), bombax (*Bombax cieba*), pine (*Pinus spp*), silver oak (*Grevillea robusta*), and wattle (*Acacia mearnsii*) are examined. As these occupy relatively small area, they are presented together.

3.3.1 Productivity

Tables 7 and 8 shows the average yield obtained from different species. The mean yield weighted with the area, yield of the lowest and highest deciles and the MAI is given.

Table: 7

Productivity of acacia, pine and wattle plantations in Kerala

Species	Mean Age	No. of Plns.	Total Area	Yield (MT ha^{-1})			MAI MT ha^{-1} yr^{-1}
				Mean	Lowest decile	Highest decile	
Acacia	8	44	1199.175	30.359	8.782	60.824	3.610
Pine	23	15	603.245	82.828	29.851	106.345	3.601
Wattle wood	10	22	822.180	32.952	8.463	75.497	3.295
Wattle bark				6.718	1.714	14.426	0.671

Table: 8

Productivity of albizia, bombax and silver oak plantations in Kerala

Species	Mean Age	No. of Plns.	Total Area	Yield (m^3 ha^{-1})			MAI m^3ha^{-1} yr^{-1}
				Mean	Lowest decile	Highest decile	
Albizia	15	15	230.995	111.986	46.355	186.623	7.466
Bombax	32	2	116.750	83.042	11.010	94.135	2.636
Silver Oak	28	1	20.700	86.574	NA	NA	3.092

As the rotations are different, productivity can be compared only in respect of MAI. It can be seen that albizia gives the highest yield per ha among all the other species. Given the price differential and end uses, comparison of MAI is not of much relevance.

3. 3. 2 Profitability

Acacia

Acacia auriculiformis plantations were the mainstay of the World Bank aided social forestry project and they were raised in different patterns such as avenue plantations, strip plantations, small blocks and large blocks.

The cash flow given in Appendix 12, uses a mean price of Rs. 550 MT^{-1}. With the mean yield of 30 m^3 ha^{-1}. The undiscounted cash flow in a rotation of 8 years shows a net loss of Rs. 9087 ha^{-1}. The profitability analysis (Table 9) shows an IRR of –6.9 and a negative NPV for the mean yield without any land rent. The benefit cost ratio is also below unity at all rates of discount considered. When land rent of Rs. 1300 and Rs.2500 are considered, the rate of losses increase.

Table : 9
NPV, BCR and IRR of acacia plantations with coppice age 8 years

Land Rent (Rs.)	Yield Level	Discount rates								IRR (%)
		6%		9%		12%		18%		
		NPV	BCR	NPV	BCR	NPV	BCR	NPV	BCR	
0	Low	-20	0.1	-20	0.1	-20	0.1	-19	0.1	-26.92
	Mean	-13	0.4	-14	0.4	-15	0.3	-16	0.2	-6.90
	High	-2	0.9	-6	0.7	-8	0.6	-11	0.4	4.22
1300	Low	-30	0.1	-29	0.1	-27	0.1	-25	0.0	-45.69
	Mean	-22	0.3	-23	0.3	-23	0.2	-22	0.2	-14.94
	High	-12	0.6	-14	0.5	-16	0.5	-18	0.3	-2.05
2500	Low	-38	0.1	-36	0.1	-35	0.1	-32	0.0	-68.30
	Mean	-31	0.3	-30	0.2	-30	0.2	-28	0.1	-21.88
	High	-20	0.5	-22	0.4	-23	0.4	-24	0.3	-7.15

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

Albizia

Albizia logs (*Paraserianthes falcataria*) are used for the sea going fishing rafts and there is a demand for them from the coastal fishing communities. It is harvested at a mean age of 15 years. As the supply of these logs is not regular or steady, the price received by the department do not reflect its value to the final consumer.

The undiscounted cash flow (see Appendix 13) shows a net return of Rs. 11,987 ha^{-1} at a price of Rs. 453 m^{-3}. The profitability analysis reveals a modest IRR of 2.39% for a mean yield of 111.9 m^{-3} ha^{-1}. However, as shown in Table 10, the NPV is negative even at 6% rate of discounting and the BC ratio is below unity.

When land rent of Rs. 1300 is considered, the IRR is positive only for the yield in the highest decile.

Table : 10

NPV, BCR and IRR of albizia plantations with coppice age 15 years

Land Rent (Rs.)	Yield Level	Discount rates								IRR (%)
		6%		9%		12%		18%		
		NPV	BCR	NPV	BCR	NPV	BCR	NPV	BCR	
0	Low	-23	0.3	-24	0.2	-24	0.1	-23	0.1	-5.51
	Mean	-11	0.7	-16	0.5	-19	0.3	-21	0.2	2.39
	High	3	1.1	-7	0.8	-13	0.6	-18	0.3	6.82
1300	Low	-37	0.2	-36	0.1	-34	0.1	-31	0.1	-11.57
	Mean	-25	0.5	-28	0.3	-29	0.2	-29	0.1	-1.60
	High	-11	0.8	-18	0.6	-23	0.4	-26	0.2	3.46
2500	Low	-50	0.1	-47	0.1	-44	0.1	-39	0.0	-17.04
	Mean	-38	0.4	-39	0.3	-38	0.2	-36	0.1	-4.87
	High	-24	0.6	-29	0.4	-32	0.3	-33	0.2	-0.10

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

Silver oak

Silver oak (*Grevillea robusta*) was traditionally raised as shade trees in tea plantations. The Forest Department also has some pure plantations of Silver Oak. The price considered was Rs. 759 m^{-3}. The undiscounted cash flow for a rotation of 28 years shows a net benefit of the 14,747 ha^{-1} (Appendix 14). The profitability analysis shows an IRR of 1.28 %. At 6 % rate of discounting the NPV is negative and the BC ratio is 0.4 even when no land rent is considered (Table 11).

Table : 11
NPV, BCR and IRR of Silver Oak plantations with rotation age 28 years

Land Rent (Rs.)	Yield Level	Discount rates								IRR (%)
		6%		9%		12%		18%		
		NPV	BCR	NPV	BCR	NPV	BCR	NPV	BCR	
0	Mean	-23	0.4	-26	0.2	-26	0.1	-25	0.0	1.28
1300	Mean	-41	0.2	-40	0.1	-38	0.1	-33	0.0	-1.75
2500	Mean	-59	0.2	-54	0.1	-49	0.1	-41	0.0	-4.18

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

Bombax

Bombax wood (*Bombax cieba*) was the mainstay of the match industries and the forest department raised pure and mixed plantations of bombax under early Five Year Plan schemes before pulpwood became more important. The price considered was Rs. 1060 m^{-3}. The cash flow from Bombax plantations (Appendix 15) shows a net benefit of Rs. 57,976 ha^{-1} for a rotation of 32 years when the mean yield is considered.

The profitability analysis show an IRR of 4.17 % for the mean yield when no land rent is considered at Rs. 1,300 and Rs. 2,500 levels of land rent per ha the IRR becomes negative (see table 12). At 6 % rate of discounting the BC ratio is 0.6 but the NPV is negative.

Table : 12
NPV, BCR and IRR of Bombax plantations with rotation age 32 years

Land Rent (Rs.)	Yield Level	Discount rates								IRR (%)
		6%		9%		12%		18%		
		NPV	BCR	NPV	BCR	NPV	BCR	NPV	BCR	
0	Low	-21	0.1	-20	0.0	-19	0.0	-17	0.0	-4.05
	Mean	-9	0.6	-15	0.3	-17	0.1	-17	0.0	4.17
	High	-7	0.7	-14	0.3	-16	0.1	-17	0.0	4.66
1300	Low	-40	0.0	-35	0.0	-31	0.0	-26	0.0	-14.25
	Mean	-28	0.3	-30	0.2	-29	0.1	-25	0.0	-0.02
	High	-26	0.4	-29	0.2	-28	0.1	-25	0.0	1.59
2500	Low	-58	0.0	-48	0.0	-42	0.0	-34	0.0	-24.40
	Mean	-46	0.2	-43	0.1	-40	0.1	-33	0.0	-1.33
	High	-45	0.3	-43	0.1	-39	0.1	-33	0.0	-0.77

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

Pine

Pines are plantation species popular all over the temperate regions for timber. In Kerala pines have been tried in the high elevation areas such as Munnar. Here pinewood is allotted to the pulp industries as pulpwood at the same rates as eucalypt wood. The undiscounted cash flow from pine plantations show (Appendix 16) that in a mean rotation of 23 years the net benefit with mean yield is Rs. 3111 ha^{-1}.

The profitability analysis shows a negative IRR of – 0.21 % for the mean yield even when no land rent is considered (Table 13). At 6 % rate of discounting the NPV is negative at the BC ratio is 0.4 for the mean yield.

Table : 13

NPV, BCR and IRR of pine plantations with rotation age 23 years

Land Rent (Rs.)	Yield Level	Discount rates								IRR (%)
		6%		9%		12%		18%		
		NPV	BCR	NPV	BCR	NPV	BCR	NPV	BCR	
0	Low	-24	0.1	-23	0.1	-22	0.0	-20	0.0	-6.21
	Mean	-17	0.4	-19	0.2	-20	0.1	-19	0.0	-0.21
	High	-14	0.5	-18	0.3	-19	0.2	-19	0.1	1.97
1300	Low	-41	0.1	-36	0.1	-33	0.0	-28	0.0	-14.65
	Mean	-34	0.2	-33	0.1	-31	0.1	-27	0.0	-3.97
	High	-31	0.3	-31	0.2	-30	0.1	-27	0.0	-2.02
2500	Low	-57	0.1	-49	0.0	-43	0.0	-36	0.0	-22.69
	Mean	-50	0.2	-46	0.1	-41	0.1	-35	0.0	-7.50
	High	-47	0.2	-44	0.1	-41	0.1	-35	0.0	-5.13

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

Wattle

Unlike other plantation trees in the forest, wattle (Acacia *mearnsii*) is raised mainly for the bark, which is an important raw material for leather tanning industry located in Tamil Nadu. The wood is allotted to the pulp industries in Kerala at the same rate as eucalypt wood. The mean price of wattle wood and bark considered are Rs. 487 MT^{-1} and Rs. 3056 MT^{-1} respectively.

The undiscounted cash flow from wattle plantations show a net benefit of Rs. 9742 ha^{-1} for mean yield in a mean rotation of 10 years (Appendix 17). The profitability analysis shows an IRR of 4.2 % when no land rent is considered. However at Rs. 1300 and Rs. 2500 levels of

land rent per ha the IRR is negative (Table 14). At 6 % rate of discounting the BC ratio is 0.9 and the NPV is negative.

Table 14

NPV, BCR and IRR of wattle plantations in Kerala

Land Rent (Rs.)	Yield Level	Discount rate								IRR (%)
		6%		9%		12%		18%		
		NPV	BCR	NPV	BCR	NPV	BCR	NPV	BCR	
0	Low	-18	0.2	-18	0.2	-18	0.1	-17	0.1	-14.3
	Mean	-3	0.9	-7	0.7	-9	0.6	-12	0.4	4.2
	High	22	1.9	12	1.5	5	1.2	-4	0.8	15.1
1300	Low	-29	0.2	-28	0.1	-27	0.1	-24	0.1	-25.5
	Mean	-14	0.6	-16	0.5	-18	0.4	-19	0.3	-1.8
	High	11	1.3	2	1.1	-4	0.9	-11	0.6	10.1
2500	Low	-39	0.1	-37	0.1	-35	0.1	-31	0.1	-36.5
	Mean	-24	0.5	-25	0.4	-26	0.3	-26	0.2	-6.5
	High	1	1.0	-6	0.8	-11	0.7	-17	0.5	6.3

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

The financial performance of eucalypts and other plantations have been an unqualified disaster. Their continuation can be justified only if it fulfils some overriding strategic or social purpose, which is difficult, at the moment, to perceive.

4. DISCUSSION

This section is primarily intended to compare the performances of different species of plantations and to rank them on the basis of profitability. So far, the profitability analysis was focussed on individual species. As the length of rotation of different species varied considerably, a direct comparison of NPV of each species is not meaningful. To overcome this problem NPV at infinity was computed.

Table 15 gives the NPV at infinity at different rates of discounting ranging from 6 to 18 percentage for different species. It can be seen that only teak has a positive NPV at infinity. Even at 18 percent rate of

discounting, the NPV at infinity for teak is Rs. 7446, whereas all other species have a negative NPV indicating loss at the current levels of productivity and prices.

Another exercise was carried out to compute the annual surplus that is available as savings or for reinvestment for different species. Table 17 gives the results of the analysis. It shows the maximum land rent possible since no rent is paid or accounted for forest plantations in Kerala. It gives the surplus that is obtained at different levels of yield. When the mean yield of different species of plantations are considered, only that of teak plantations generate a positive annual surplus. At 6% rate of discounting, the annual surplus or maximum possible annual rent for teak is Rs. 7250 ha^{-1} for mean yield, while at 18% rate of discounting the annual surplus is Rs. 1250. At 12% rate of discount the maximum land rent or surplus is Rs. 2750 for plantations with mean yield and Rs. 8500 for plantations with high yield. For all other species, the surplus is negative even at 6% rate of discounting. It shows that the forest department is incurring an annual deficit. For eucalypts the annual deficit is Rs. 2800 ha^{-1} at 12% rate of discounting and for acacia the deficit is Rs. 2500 ha^{-1}.The maximum surplus corresponding to the low and high yields are also given in Appendix 18. When the low level of yield is considered, only teak fetches a surplus of Rs. 1000 ha^{-1} at 6% rate of discounting, while at 9% and above there occur an annual deficit even at 6%, for others. When the high level of yield is considered the annual surplus for teak plantations is Rs.18,000 ha^{-1} at 6% and Rs. 5,500 at 18 % rate of discounting. For eucalypts and wattle there is a surplus at 12% but not at 18%. In the case of acacia, albizia, bombax, silver oak and pine there is a deficit at 6% and higher rate of discounting. The preceding analysis showed that at the mean level of yield and the current cost structure, only teak plantations are profitable. The plantations of eucalypts and other species bring only loss. For teak, the timber and poles are sold in open auction while most other species are sold to the pulp industry at a pre-determined price annually announced by the government.

Here an attempt is made to arrive at a price, which can offset the loss. Table 16 shows the minimum level of price per tonne of plantation wood at different rates of land rents. Land rent is considered at three levels – no rent, Rs. 1300 ha^{-1} yr^{-1} and Rs. 2500 ha^{-1} yr^{-1}. As the Forest Department manages forest plantations in Reserved Forests, in actual practice no land rent is paid or accounted. However when forestland is leased to public sector corporations such as Plantation Corporation of Kerala (PCK) a land rent is charged. Rupees 1300 $ha^{-1}yr^{-1}$

was the land rent for more than a decade now. It is due for revision. An anticipated level of rent at Rs 2500 ha $^{-1}$ yr $^{-1}$ is thus considered.

Table 15

Net Present Value at infinity of forest plantations

Species	Mean Age	NPV at infinity (Rs. ha^{-1})			
		6%	9%	12%	18%
Teak	58	125371	48449	24031	7446
Eucalypts	8	-35255	-29969	-27148	-23985
Pine	23	-22838	-22178	-21262	-19438
Acacia	8	-34718	-28235	-24904	-21392
Albizia	15	-18847	-21988	-22964	-22900
Bombax	32	-10304	-16880	-17233	-16897
Silver oak	28	-28305	-28477	-27542	-25216
Wattle	10	-6721	-11425	-13442	-14838

Table 16

Minimum Price of plantation wood in Rs. MT^{-1} at different rates of discounting and different land rents

Species	Land Rent (Rs. ha^{-1})	Rate of discounting			
		6%	9%	12%	18%
Acacia	0	1250	1475	1775	2500
	1300	1725	2050	2400	3325
	2500	2200	2550	3000	4075
Eucalypts	0	900	1075	1275	1775
	1300	1200	1400	1650	2275
	2500	1475	1700	2000	2725
Pine	0	1275	2175	3725	10825
	1300	2075	3375	5575	15375
	2500	2800	4500	7300	19575
Wattle*	0	650	975	1350	2400
	1300	1250	1675	2175	3550
	2500	1800	2300	2925	4600

*Yield from Wattle bark is estimated as 6.718MT ha^{-1} and its price is considered to remain at Rs. 3056 MT^{-1}

Table 17

Maximum Surplus or Land Rent possible (in Rs ha^{-1} $year^{-1}$) for different species with mean yields at different rates of discounting

Species	Age	Rate of discounting			
		6%	9%	12%	18%
Teak	58	7250	4000	2750	1250
Eucalypt	8	-1900	-2300	-2800	-3500
Acacia	8	-1800	-2200	-2500	-3100
Albizia	15	-1100	-1800	-2500	-3500
Silver oak	28	-1600	-2400	-3000	-3900
Bombax	32	-600	-1400	-1900	-2600
Pine	23	-1300	-1900	-2300	-3000
Wattle	10	-360	-890	-1380	-2190

At current levels of productivity and costs (see table 16) at 12 percent rate of discounting with a land rent of Rs. 2500 ha^{-1} yr^{-1}, the minimum price of eucalypt wood should be Rs. 2000 MT^{-1}, for acacia Rs. 3000 MT^{-1}, for pine Rs. 7300 MT^{-1}, and for wattle wood Rs 2925 (while wattle bark price remains at Rs. 3056 MT^{-1}).

As in the case of most commercial ventures of the government, a very optimistic level of output is assumed, even when the loses accumulate the activities continue for many more years or decades. For example the disparity between the cost of production and the price at which it was contracted to be supplied to the pulp units was estimated by Nair (1977). Further annual loss in the sale of eucalypt wood to the pulp factories during the early 1980's was calculated as Rs.6.7 million (Krishnankutty and Chundamannil 1985). The loss suffered is in effect a subsidy enjoyed by the industry. And in the final analysis a policy decision takes into consideration a host of factors among which commercial profitability is just one element.

Conservation ideas came to be seriously debated and considered only in the eighties. Most of the plantation expansion took place in the preceding two or three decades. The precedence of the Five Year Plans over the Divisional Forest Working Plans and the system of resource allocation which provided for Plan funding for plantation establishment and nothing for the maintenance of the plantations encouraged the conversion of natural forests to plantations but did not give sufficient importance the aftercare and productivity. The pro industry pricing policy deprived the forest department of the resources necessary for the sustainability of the production process.

Forest Plantations in Kerala are managed on a low input conservative approach. The productivity achieved is lower than that projected by the Patterson's index or by the site quality of the areas selected for raising the plantations. Whether a higher financial or material input will result in a higher productivity is debatable. But definitely a higher level of managerial input giving priority to quality up gradation in all aspects from the selection of planting material and site to the felling and marketing will improve the situation greatly. A system for regular monitoring, quicker decision-making and timely operations is vital.

As evident from the yields obtained and field inspections, there are many plantations standing on unsuitable sites. Most of these plantations were raised during the 1960's and 70's to meet certain Five Year Plan Targets without reference to the Working Plan recommendations. The industry focussed National Forest Policy of 1952 has been replaced by the Conservation focussed Policy of 1988. Given the high priority for biodiversity conservation and the need to maintain sufficiently viable tracts of continuous natural vegetation for the sustainability of the genetic base of the indigenous flora and fauna, it is high time to carefully consider the option of reverting some of these plantations back to the original natural vegetation. This will allow the Forest Department to give the attention necessary to achieve and maintain high levels of productivity in good plantation sites.

It is high time to review the quality of the forest plantations in an economic as well as conservation perspectives. While the more promising plantations should be given all the care and attention, others which are economic disasters and which could better provide conservation values should be nursed back to the original natural vegetation of the locality. This as already happening in the case of the teak plantations in some of the wild life sanctuaries where the final felling is replaced by selection felling and the natural vegetation is

allowed to return to the area. Considering the economic value of the non-wood forest produce from the natural forests and the conservation value of the remaining forests in the Western Ghats, a reappraisal is in order. Just because a natural forest has been converted to a plantation it should not be a justification for its continuance as one or the other plantation indefinitely. The important question should be, is it the optimum land use in the particular site? The issue to be discussed thoroughly in the case of our biologically rich forests is, how efficient are the different land use options in the conservation of biodiversity, sustainability of water yields in the rainless months and availability of forest produce and environmental benefits for the coming generations.

As a responsible society we have to accept that not all plantations will succeed in all places. Some are bound to fail. A failed plantation site need not necessarily be handed over or leased to some other agency as if the forest department is incapable of managing the area. The forest department should manage the forests on behalf of the citizens and not lease out any more areas to private industries or other government agencies for plantation establishment or maintenance. In the land scarce, politically sensitive social milieu of Kerala one must realise that it is practically impossible to retrieve forestlands leased to any agency. The numerous private plantations of tea, cardamom and rubber, many of which are time expired leases continue to be in the hands of de facto owners without even paying the very nominal annual lease rent.

Government plantation companies such as the Plantations Corporation of Kerala (PCK), Rehabilitation Plantations Limited (RPL), State Farming Corporation of Kerala (SFCK), Oil Palm India Limited (OIL) and Kerala Forest Development Corporation (KFDC) have established plantations in the forests. A review of the economic and conservation impact of these plantation experiments would also be an eye opener to the control the Forest Department has in their activities. The irreversibility of many actions particularly when another agency has acquired even a temporary right is a fact of life in Kerala's social and political environment. Therefore, it is imperative that forest lands or plantations should remain with the Forest Department and not be alienated or leased to other agencies. The National Forest Policy is very clear and specific on this subject.

When the Forest Department revenues came from clear felling and selection felling in natural forests, the investment in plantations in fact added to the immediate revenues by clear felling natural forests (Chundamannil 1986). The commercial viability of the plantations were not given great importance, primarily due to the assumption of high

yields. Even when contracts for pulpwood supply to industrial units were signed, a concessional rate was adopted for attracting industries to the state. Being a government department no mechanism to offset the loss due to concessional supply has been evolved.

There has been a great change in the approach to plantation establishment and expansion in the last decades. In the sixties and seventies the thrust was in rapid expansion of area of all plantations particularly of pulpwood, in the eighties the pace slackened and in the nineties the expansion of plantation area came to a halt reflecting the changing focus of the forest policy.

The rapid increase in plantation area was not matched with the funding and continuing maintenance of the plantations created. While new plantations were funded from the assured plan funds, money for subsequent maintenance had to come from the non-plan budget.

In retrospect, it can be seen that the priority for area expansion did not have a matching priority for productivity enhancement or even maintenance. An indication of a declining productivity from teak plantation in Nilambur is available from an earlier study by KFRI (Chundamannil 1998). It wouldn't be surprising if a similar trend were noticed in the case of other plantations also.

Eucalypt plantations faced several problems like site species mis-matching, termite damage, diseases in nurseries and plantations etc. Ensuring sufficient regeneration in the coppice felled areas for the second and subsequent rotations were also problems in some sites. Frequent fires too damaged large areas of eucalypt plantations, which did not have the resilience of teak in fire prone areas.

The other plantations were started on an experimental basis or in response to demand for industrial raw material requirement, without adequate pilot studies to standardise the spacing and scheduling of management operations and inputs required. After an initial fancy, none of them took off due to various reasons. With the level of productivity achieved and the financial performance it was best that expansion halted.

An important question that remains is what should be done to the low productive or failed plantations. The traditional response has been to shift the crop from one species to another say eucalypts to teak plantations and back to eucalypts or some other species, without really

going onto the causes for the failure. In the effort to find sites to meet the high targets for new planting which was not envisaged in the Working Plans, many unsuitable areas were also included. Some very steep areas, some rocky areas were also clearfelled and planted. With high biotic pressure and fire, poor areas became marginalised and shifting from one plantation species to another is not a solution. What is required is a sober reappraisal of the forest land use in the state. Liberalization has already resulted in falling prices of imported wood and pulp. We need to look beyond wood production and far into the future.

5. CONCLUSIONS

In the forest plantations of Kerala, under the prevailing level of productivity and prices, only teak is profitable whereas species such as eucalypt, acacia, albizia, bombax, silver oak, pine and wattle cause severe loss. While teak is sold in regular auctions at government depots, other species are either sold standing or supplied to the pulp units in the state at a price lower than the market price. The losses observed in the case of eucalypts and other species is primarily due the high variability in the yields and the system of pricing adopted. The loses can be minimised if a more realistic price is fixed. As the Forest Produce Fixation of Selling Price Act 1978 is in force there is no obstacle in announcing a reasonable price reflecting the cost of production and the opportunity cost of the land. More over the National Forest Policy do not support subsidised supply of forest raw materials to industries. The losses can also be minimised if uneconomic plantations are phased out and reverted to natural mixed forests to serve the primary function of forests.

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LIST OF APPENDICES

Appendix 1
Division wise Distribution of Teak plantations from which yield data was obtained

Division	No. of plantations	Area (ha.)
Chalakkudy	25	2052.820
Konni	35	1035.272
Kothamangalam	35	2066.813
Kottayam	10	498.341
Nilambur North	209	5802.675
Nilambur South	165	6872.711
Parambikulam	11	512.235
Punalur	30	1156.940
Ranni	23	966.643
Thenmala	49	1363.779
Trichur	1	70.00
Vazhachal	24	2401.174
Wynad North	31	1064.920
Wynad South	12	695.670
Wynad Wildlife	57	2242.025
Total	717	28802.018

Appendix 2

Expected yields from thinnings in teak plantations in different Site qualities

Age	Site quality						
	I	I/II	II	II/III	III	III/IV	IV
6	22.32	21.13	19.24	16.72	13.85	2.17	1.47
7	23.65	22.32	20.29	17.35	14.06	4.34	2.94
8	24.98	23.51	21.34	17.98	14.27	6.51	4.41
9	26.31	24.70	22.39	18.61	14.48	8.68	5.88
10	27.64	25.89	23.44	19.24	14.69	10.85	7.35
11	28.20	26.31	23.72	19.38	14.76	10.78	7.28
12	28.76	26.73	24.00	19.52	14.83	10.71	7.21
13	29.32	27.15	24.28	19.66	14.90	10.64	7.14
14	29.88	27.57	24.56	19.80	14.97	10.57	7.07
15	30.44	27.99	24.84	19.94	15.04	10.50	7.00
16	31.84	28.69	24.91	19.73	14.83	10.36	6.86
17	33.24	29.39	24.98	19.52	14.62	10.22	6.72
18	34.64	30.09	25.05	19.31	14.41	10.08	6.58
19	36.04	30.79	25.12	19.10	14.20	9.94	6.44
20	37.44	31.49	25.19	18.89	13.99	9.80	6.30
21	37.44	31.56	24.98	18.54	13.85	9.66	6.16
22	37.44	31.63	24.77	18.19	13.71	9.52	6.02
23	37.44	31.70	24.56	17.84	13.57	9.38	5.88
24	37.44	31.77	24.35	17.49	13.43	9.24	5.74
25	37.44	31.84	24.14	17.14	13.29	9.10	5.60
26	35.48	30.16	23.16	16.51	13.01	8.96	5.46
27	33.52	28.48	22.18	15.88	12.73	8.82	5.32
28	31.56	26.80	21.20	15.25	12.46	8.68	5.18
29	29.60	25.12	20.22	14.62	12.18	8.54	5.04

Age	Site quality						
	I	I/II	II	II/III	III	III/IV	IV
30	27.64	23.44	19.24	13.99	11.90	8.40	4.90
31	26.73	22.81	18.89	13.92	11.55	8.19	4.76
32	25.82	22.18	18.54	13.85	11.20	7.98	4.62
33	24.91	21.55	18.19	13.78	10.85	7.77	4.48
34	24.00	20.92	17.84	13.71	10.50	7.56	4.34
35	23.09	20.29	17.49	13.64	10.15	7.35	4.20
36	22.39	19.73	17.00	13.36	10.01	7.21	4.06
37	21.69	19.17	16.51	13.08	9.87	7.07	3.92
38	20.99	18.61	16.02	12.80	9.73	6.93	3.78
39	20.29	18.05	15.53	12.53	9.59	6.79	3.64
40	19.59	17.49	15.04	12.25	9.45	6.65	3.50
41	18.96	16.93	14.62	12.04	9.31	6.51	3.43
42	18.33	16.37	14.20	11.83	9.17	6.37	3.36
43	17.70	15.81	13.78	11.62	9.03	6.23	3.29
44	17.07	15.25	13.36	11.41	8.89	6.09	3.22
45	16.44	14.69	12.94	11.20	8.75	5.95	3.15

Source : Extrapolated from FRI & C 1970

Appendix 3

Expected yields from final felling in teak plantations in different Site qualities (in m^3 ha^{-1})

Age	Site quality						
	I	I/II	II	II/III	III	III/IV	IV
40	211.32	176.33	144.49	122.10	98.31	78.02	58.08
41	216.14	179.97	147.57	123.43	99.43	79.00	58.71
42	220.97	183.61	150.65	124.76	100.55	79.98	59.34
43	225.80	187.25	153.73	126.09	101.67	80.96	59.97
44	230.63	190.88	156.81	127.42	102.79	81.94	60.60
45	235.46	194.52	159.89	128.75	103.91	82.92	61.23
46	240.21	198.58	162.69	130.57	105.03	83.97	62.14
47	244.97	202.64	165.48	132.39	106.15	85.02	63.05
48	249.73	206.70	168.28	134.21	107.27	86.07	63.95
49	254.49	210.76	171.08	136.03	108.39	87.12	64.86
50	259.25	214.81	173.88	137.85	109.51	88.17	65.77
51	263.38	218.45	176.89	140.15	110.91	88.86	66.75
52	267.50	222.09	179.90	142.46	112.31	89.56	67.73
53	271.63	225.73	182.91	144.77	113.70	90.26	68.71
54	275.76	229.37	185.92	147.08	115.10	90.96	69.69
55	279.89	233.01	188.93	149.39	116.50	91.66	70.67
56	283.53	236.44	192.14	151.98	118.25	92.85	71.58
57	287.17	239.87	195.36	154.57	120.00	94.04	72.49
58	290.80	243.29	198.58	157.16	121.75	95.23	73.40
59	294.44	246.72	201.80	159.75	123.50	96.42	74.31
60	298.08	250.15	205.02	162.34	125.25	97.61	75.22
61	301.65	253.16	207.68	164.78	127.35	98.73	76.41
62	305.22	256.17	210.34	167.23	129.45	99.85	77.60
63	308.79	259.18	213.00	169.68	131.55	100.97	78.79
64	312.36	262.19	215.65	172.13	133.65	102.09	79.98
65	315.92	265.20	218.31	174.58	135.75	103.21	81.17
66	318.79	268.13	220.83	177.45	137.92	104.96	82.36
67	321.66	271.07	223.35	180.32	140.08	106.71	83.55
68	324.53	274.01	225.87	183.19	142.25	108.46	84.74
69	327.40	276.95	228.39	186.06	144.42	110.21	85.93
70	330.27	279.89	230.91	188.93	146.59	111.96	87.12

Source : Extrapolated from FRI & C 1970

Appendix 4

Percentage distribution of yields 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^{-1})												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	15	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	64	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^{-1})										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 5

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

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

Appendix 6

Cash flow 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	2144.96	33919.46	31774.50
	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	3740.46	48340.42	44599.96
	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

Type of work	Age (Yr.)	Cost (Rs)	Benefit (Rs)	Net benefit (Rs)
	29	358.00	0.00	-358.00
3 Silvi. thinning	30	3290.69	113039.64	109748.95
	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	16053.16	145546.15	129492.99
	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	33568.14	1529039.91	1495471.77
Total		100383.22	1923610.44	1823227.23

Appendix 7
Division wise Distribution of Eucalypt plantations
from which yield data was obtained

Division	No. of plantations	Total Area (ha)
Aralam	2	167.000
Konni	1	99.848
Kothamangalam	4	332.550
Kottayam	7	7.000
Kozhikode	12	12.000
Malayattur	5	5.000
Mannarkadu	2	100.000
Munnar	38	38.000
Nenmara	2	97.270
Nilambur North	11	11.000
Parambikulam	1	25.000
Peerumedu	148	148.000
Periyar WL	1	189.375
Punalur	27	1,627.500
Thenmala	14	754.895
Thrissur	69	69.000
Trivandrum	84	84.000
Trivandrum WL	7	334.900
Vazhachal	10	10.000
Wyanad North	24	24.000
Wyanad South	20	20.000
Wyanad WL	38	38.000
KFDC-Punalur	17	859.010
KFDC-Trichur	9	1,717.077
KFDC-Trivandrum	18	1,394.865
Total	571	39,083.930

Appendix 8

Cash flow from Eucalypt plantations (in Rs ha^{-1})

Age	Cost	Low yield		Mean yield		High yield	
		Benefit	Net benefit	Benefit	Net benefit	Benefit	Net benefit
0	4751.70	0.00	-4751.70	0.00	-4751.70	0.00	-4751.70
1	13808.30	0.00	-13808.30	0.00	-13808.30	0.00	-13808.30
2	5564.80	0.00	-5564.80	0.00	-5564.80	0.00	-5564.80
3	3337.84	0.00	-3337.84	0.00	-3337.84	0.00	-3337.84
4	940.00	0.00	-940.00	0.00	-940.00	0.00	-940.00
5	940.00	0.00	-940.00	0.00	-940.00	0.00	-940.00
6	940.00	0.00	-940.00	0.00	-940.00	0.00	-940.00
7	940.00	0.00	-940.00	0.00	-940.00	0.00	-940.00
8	940.00	1421.55	481.55	25059.07	24119.07	87804.15	86864.15
	32162.64	1421.55	-30741.09	25059.07	-7103.57	87804.15	55641.51

Appendix 9

Division wise distribution of Acacia, Albizia, Bombax, Silver oak, Pine and Wattle plantations covered

Species	Division	No. of plantations	Area (ha.)
Acacia	Punalur	20	312.55
	Thenmala	3	26.68
	Trivandrum	8	68.26
	Trichur	13	791.68
	Acacia Total	44	1199.175
Albizia	Vazhachal	15	230.995
Bombax	Achencovil	1	15.58
	Vazhachal	1	101.17
	Bombax Total	2	116.75
Silver Oak	Vazhachal	1	20.7
Pine	Munnar	15	603.245
Wattle	Munnar	22	822.18

Appendix 10

Price of wood from Acacia, Eucalypts, Pine and Wattle plantations considered for the analysis

Species	Rs. MT^{-1}
Eucalypts	487
Acacia	550
Pine	487
Wattle wood	487
Wattle bark	3056

Appendix 11

Price of wood from Albizia, Bombax and Silver Oak plantations considered for the analysis

Species	Rs. m^{-3}
Albizia	453
Silver oak	759
Bombax	1060

Appendix 12

Cash flow from Acacia plantations in Kerala (in Rs ha^{-1})

Age	Cost	Low yield		Mean yield		High yield	
		Benefit	Net benefit	Benefit	Net benefit	Benefit	Net benefit
0	4751.00	0.00	-4751.00	0.00	-4751.00	0.00	-4751.00
1	13521.00	0.00	-13521.00	0.00	-13521.00	0.00	-13521.00
2	2462.00	0.00	-2462.00	0.00	-2462.00	0.00	-2462.00
3	1066.00	0.00	-1066.00	0.00	-1066.00	0.00	-1066.00
4	797.00	0.00	-797.00	0.00	-797.00	0.00	-797.00
5	797.00	0.00	-797.00	0.00	-797.00	0.00	-797.00
6	797.00	0.00	-797.00	0.00	-797.00	0.00	-797.00
7	797.00	0.00	-797.00	0.00	-797.00	0.00	-797.00
8	797.00	4830.10	4033.10	16697.45	15900.45	33453.20	32656.20
	25785.00	4830.10	-20954.90	16697.45	-9087.55	33453.20	7668.20

Appendix 13

Cash flow from Albizia plantations in Kerala (in Rs ha^{-1})

Age	Cost	Low yield		Mean yield		High yield	
		Benefit	Net benefit	Benefit	Net benefit	Benefit	Net benefit
0	4751.70	0.00	-4751.70	0.00	-4751.70	0.00	-4751.70
1	13808.30	0.00	-13808.30	0.00	-13808.30	0.00	-13808.30
2	5564.80	0.00	-5564.80	0.00	-5564.80	0.00	-5564.80
3	3337.84	0.00	-3337.84	0.00	-3337.84	0.00	-3337.84
4	940.00	0.00	-940.00	0.00	-940.00	0.00	-940.00
5	940.00	0.00	-940.00	0.00	-940.00	0.00	-940.00
6	940.00	0.00	-940.00	0.00	-940.00	0.00	-940.00
7	940.00	0.00	-940.00	0.00	-940.00	0.00	-940.00
8	940.00	0.00	-940.00	0.00	-940.00	0.00	-940.00
9	940.00	0.00	-940.00	0.00	-940.00	0.00	-940.00
10	940.00	0.00	-940.00	0.00	-940.00	0.00	-940.00
11	940.00	0.00	-940.00	0.00	-940.00	0.00	-940.00
12	940.00	0.00	-940.00	0.00	-940.00	0.00	-940.00
13	940.00	0.00	-940.00	0.00	-940.00	0.00	-940.00
14	940.00	0.00	-940.00	0.00	-940.00	0.00	-940.00
15	940.00	20998.82	20058.82	50729.66	49789.66	84540.22	83600.22
	38742.64	20998.82	-17743.82	50729.66	11987.02	84540.22	45797.58

Appendix 14
Cash flow from silver oak plantations in Kerala (in Rs ha^{-1})

Age (Yr)	Cost (Rs)	Benefit (Rs)	Net benefit (Rs)
0	4751.70	0.00	-4751.70
1	13808.30	0.00	-13808.30
2	5564.80	0.00	-5564.80
3	3337.84	0.00	-3337.84
4	940.00	0.00	-940.00
5	940.00	0.00	-940.00
6	940.00	0.00	-940.00
7	940.00	0.00	-940.00
8	940.00	0.00	-940.00
9	940.00	0.00	-940.00
10	940.00	0.00	-940.00
11	940.00	0.00	-940.00
12	940.00	0.00	-940.00
13	940.00	0.00	-940.00
14	940.00	0.00	-940.00
15	940.00	0.00	-940.00
16	940.00	0.00	-940.00
17	940.00	0.00	-940.00
18	940.00	0.00	-940.00
19	940.00	0.00	-940.00
20	940.00	0.00	-940.00
21	940.00	0.00	-940.00
22	940.00	0.00	-940.00
23	940.00	0.00	-940.00
24	940.00	0.00	-940.00
25	940.00	0.00	-940.00
26	940.00	0.00	-940.00
27	940.00	0.00	-940.00
28	940.00	65709.67	64769.67
	50962.64	65709.67	14747.03

Appendix 15

Cash flow from Bombax plantations in Kerala (in Rs ha^{-1})

Age	Cost	Low yield		Mean yield		High yield	
		Benefit	Net benefit	Benefit	Net benefit	Benefit	Net benefit
0	3825.00	0.00	-3825.00	0.00	-3825.00	0.00	-3825.00
1	8735.00	0.00	-8735.00	0.00	-8735.00	0.00	-8735.00
2	4562.00	0.00	-4562.00	0.00	-4562.00	0.00	-4562.00
3	2545.00	0.00	-2545.00	0.00	-2545.00	0.00	-2545.00
4	358.00	0.00	-358.00	0.00	-358.00	0.00	-358.00
5	358.00	0.00	-358.00	0.00	-358.00	0.00	-358.00
6	358.00	0.00	-358.00	0.00	-358.00	0.00	-358.00
7	358.00	0.00	-358.00	0.00	-358.00	0.00	-358.00
8	358.00	0.00	-358.00	0.00	-358.00	0.00	-358.00
9	358.00	0.00	-358.00	0.00	-358.00	0.00	-358.00
10	358.00	0.00	-358.00	0.00	-358.00	0.00	-358.00
11	358.00	0.00	-358.00	0.00	-358.00	0.00	-358.00
12	358.00	0.00	-358.00	0.00	-358.00	0.00	-358.00
13	358.00	0.00	-358.00	0.00	-358.00	0.00	-358.00
14	358.00	0.00	-358.00	0.00	-358.00	0.00	-358.00
15	358.00	0.00	-358.00	0.00	-358.00	0.00	-358.00
16	358.00	0.00	-358.00	0.00	-358.00	0.00	-358.00
17	358.00	0.00	-358.00	0.00	-358.00	0.00	-358.00
18	358.00	0.00	-358.00	0.00	-358.00	0.00	-358.00
19	358.00	0.00	-358.00	0.00	-358.00	0.00	-358.00
20	358.00	0.00	-358.00	0.00	-358.00	0.00	-358.00
21	358.00	0.00	-358.00	0.00	-358.00	0.00	-358.00
22	358.00	0.00	-358.00	0.00	-358.00	0.00	-358.00
23	358.00	0.00	-358.00	0.00	-358.00	0.00	-358.00
24	358.00	0.00	-358.00	0.00	-358.00	0.00	-358.00
25	358.00	0.00	-358.00	0.00	-358.00	0.00	-358.00
26	358.00	0.00	-358.00	0.00	-358.00	0.00	-358.00
27	358.00	0.00	-358.00	0.00	-358.00	0.00	-358.00
28	358.00	0.00	-358.00	0.00	-358.00	0.00	-358.00
29	358.00	0.00	-358.00	0.00	-358.00	0.00	-358.00
30	358.00	0.00	-358.00	0.00	-358.00	0.00	-358.00
31	358.00	0.00	-358.00	0.00	-358.00	0.00	-358.00
32	358.00	11670.60	11312.60	88024.52	87666.52	99783.10	99425.10
	30049.00	11670.60	-18378.40	88024.52	57975.52	99783.10	69734.10

Appendix 16

Cash flow from Pine plantations in Kerala (in Rs ha^{-1})

Age	Cost	Low yield		Mean yield		High yield	
		Benefit	Net benefit	Benefit	Net benefit	Benefit	Net benefit
0	2903.00	0.00	-2903.00	0.00	-2903.00	0.00	-2903.00
1	11937.00	0.00	-11937.00	0.00	-11937.00	0.00	-11937.00
2	3315.00	0.00	-3315.00	0.00	-3315.00	0.00	-3315.00
3	3131.00	0.00	-3131.00	0.00	-3131.00	0.00	-3131.00
4	797.00	0.00	-797.00	0.00	-797.00	0.00	-797.00
5	797.00	0.00	-797.00	0.00	-797.00	0.00	-797.00
6	797.00	0.00	-797.00	0.00	-797.00	0.00	-797.00
7	797.00	0.00	-797.00	0.00	-797.00	0.00	-797.00
8	797.00	0.00	-797.00	0.00	-797.00	0.00	-797.00
9	797.00	0.00	-797.00	0.00	-797.00	0.00	-797.00
10	797.00	0.00	-797.00	0.00	-797.00	0.00	-797.00
11	797.00	0.00	-797.00	0.00	-797.00	0.00	-797.00
12	797.00	0.00	-797.00	0.00	-797.00	0.00	-797.00
13	797.00	0.00	-797.00	0.00	-797.00	0.00	-797.00
14	797.00	0.00	-797.00	0.00	-797.00	0.00	-797.00
15	797.00	0.00	-797.00	0.00	-797.00	0.00	-797.00
16	797.00	0.00	-797.00	0.00	-797.00	0.00	-797.00
17	797.00	0.00	-797.00	0.00	-797.00	0.00	-797.00
18	797.00	0.00	-797.00	0.00	-797.00	0.00	-797.00
19	797.00	0.00	-797.00	0.00	-797.00	0.00	-797.00
20	797.00	0.00	-797.00	0.00	-797.00	0.00	-797.00
21	797.00	0.00	-797.00	0.00	-797.00	0.00	-797.00
22	797.00	0.00	-797.00	0.00	-797.00	0.00	-797.00
23	797.00	14537.44	13740.44	40337.24	39540.24	51790.02	50993.02
	37226.00	14537.44	-22688.56	40337.24	3111.24	51790.02	14564.02

Appendix 17

Cash flow from Wattle plantations in Kerala (in Rs ha^{-1})

Age	Cost	Low yield		Mean yield		High yield	
		Benefit	Net benefit	Benefit	Net benefit	Benefit	Net benefit
0	3041.09	0.00	-3041.09	0.00	-3041.09	0.00	-3041.09
1	10716.56	0.00	-10716.56	0.00	-10716.56	0.00	-10716.56
2	4160.21	0.00	-4160.21	0.00	-4160.21	0.00	-4160.21
3	3337.84	0.00	-3337.84	0.00	-3337.84	0.00	-3337.84
4	797.21	0.00	-797.21	0.00	-797.21	0.00	-797.21
5	797.21	0.00	-797.21	0.00	-797.21	0.00	-797.21
6	797.21	0.00	-797.21	0.00	-797.21	0.00	-797.21
7	797.21	0.00	-797.21	0.00	-797.21	0.00	-797.21
8	797.21	0.00	-797.21	0.00	-797.21	0.00	-797.21
9	797.21	0.00	-797.21	0.00	-797.21	0.00	-797.21
10	797.21	9359.47	8562.26	36577.83	35780.62	80852.90	80055.69
	26836.17	9359.47	-17476.70	36577.83	9741.66	80852.90	54016.73

Appendix 18

Maximum Surplus or Land Rent possible for different species with low and high yields at different rates of discounting (in Rs ha^{-1} yr^{-1})

Species	Age	Low Yield				High Yield			
		Rate of discounting				Rate of discounting			
		6%	9%	12%	18%	6%	9%	12%	18%
Teak	58	1000	-340	-860	-1390	18000	11500	8500	5500
Eucalypts	8	-3900	-4100	-4400	-4800	3700	2600	1600	-200
Acacia	8	-2900	-3100	-3300	-3800	-400	-900	-1400	-2300
Albizia	15	-2200	-2700	-3100	-3900	-300	-800	-1700	-3000
Silver oak	28	-1600	-2400	-3000	-3900	-1600	-2400	-3000	-3900
Bombax	32	-1400	-1800	-2100	-2700	-500	-1300	-1900	-2600
Pine	23	-1800	-2200	-2500	-3100	-1100	-1700	-2200	-3000
Wattle	10	-2180	-2440	-2690	-3140	2700	1700	800	-650