KFRI Research Report 66

A DATA BANK FOR FORESTRY SECTORIN KERALA

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PEECHI, THRISSUR

July 1990 Pages: 27

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ABSTRACT

An attempt was made to gather some of the available data related to forestry in Kerala and to generate certain useful information. The results include the following.

The actual area under forests in Kerala is far below the area of 11,225 km^2 under forests by legal status during 1987-88. An estimate provided by the Forest .Survey of India, Dehra Dun for the 1985-87 period is 10,149 km^2. The area under forest plantations has been increasing at a compound rate of 5.18 percent per annum during the period 1956-57 to 1987-88. Teak and eucalypts account for the major share of the area under plantations. Over the period 1956-57 to 1987-88 the total expenditure in real terms was increasing. The period 1965-1980 was characterised by relatively more production of timber, poles, firewood and charcoal and the revenue in real terms was also on the increase. However, the revenue after 1979-80 was declining mainly due *to* the reduction in the out-turn of forest products.

A computerized data base and retrieval system was developed for plantations in Kerala, with reference year 1987-88. The system can instantly retrieve information pertaining to any set of plantations in the State with regard to the location, species and year of planting. The utility of such a management information system is demonstrated by making projections of yield from teak plantations in Kerala for a full rotation age in the future.

A study on first rotation yield from eucalypt plantations in Kerala indicated that *Eucalyptus tereticornis* gives an average yield of 72.59 $m^3 ha^{-1}$ at 10 years whereas *E. grandis* yields upto 137.64 $m^3 ha^{-1}$ at the same age. Large variation in yield within regions precluded the discovery of any inter-regional differences. Differences in the initial espacement did not have much influence on yield, probably due to high mortality caused by extraneous factors. Larger plantations in general exhibited lower yield levels.

Mean annual rainfall recorded in some of the important catchments in Kerala is presented. A study of the variation showed significant differences between the catchments with respect to rainfall.

A study on timber prices showed either no or weak relation between current price and lagged values of price and disposal for eight species in Kerala. Price forecasting based on exponential smoothing fared better but predictions in general were not satisfactory.

The report brings out the need for a more reliable data base and studies to utilize such data effectively.

1. INTRODUCTION

Forestry sector plays an important role in the economy of Kerala. A reliable data base is a prerequisite for sound planning and the peculiar features of forestry make it all the more essential. However, information on many important aspects of the sector is lacking. This is a factor which adversely affects overall planning and development. An attempt is made here to gather some of the available information and to make an overall appraisal of the situation. Data on several aspects covered in this report can be found in detail in the annual Administration Reports of the Kerala Forest Department. No attempt is made to reproduce them here.

The report is organized in five major sections. The first section furnishes data on area, production, revenue and expenditure pertaining to the forests in Kerala since the period of formation of the State. A computerized plantation management information system is described in the section following and its uses discussed. This is followed by a report on the study of variation in yields from eucalypt plantations in Kerala. In the next section an assessment of the regional variation in rainfall over different river basins in the State is made. Further, some attempts made on forecasting future trends in timber prices in Kerala are detailed.

Since the initiation of the project in 1977, an interim report entitled 'Yield from Teak Plantations in Kerala' has been published in 1979 by the Institute. Though a list of plantations in the State was prepared around 1979 there were constraints in making the necessary field checks. The project was reformulated in 1984 and the results reported here are mainly with reference to the work done after 1984. The data on plantations which is supposed to have been verified by the Forest Department, were collected for a second time in 1987 from the Department.

2. TRENDS IN AREA, PRODUCTION, REVENUE AND EXPENDITURE PERTAINING TO THE FORESTS IN KERALA

The data on area under forests, plantations of different species, production of timber, poles, firewood and charcoal, revenue and expenditure were compiled from the Administration Reports of the Kerala Forest Department for the period 1956-57 to 1987-88 (Government of Kerala, 1956-57 to 1987-88). The revenue and expenditure were converted into real terms by deflating them with the All India Wholesale Price Indices with base year 1970-71 for analysing the trend.

2 1 Area under forests

Forests include all areas of land proclaimed to be forests, reserved, protected or others under a forest law. In Kerala, the areas which have been diverted to non-forestry purposes continue to be considered as forests by the Forest Department. Thus, the area under forests by legal status during 1987-88 is 11,225 km^2 which accounts for 29 percent of the total geographical area of the State. This does not include an area of 271 km^2 under various social forestry programmes outside forests. However, the effective forest area in 1970 has been estimated as 9400 km^2 (Chandrasekharan, 1973). According to the National Remote Sensing Agency, the area under forests in Kerala during 1972-75 was 8611 km^2 and during 1980-82 it was 7376 km^2. The reconciled figure brought about jointly by the National Remote Sensing Agency and the Forest Survey of India for 1981-83 is 10,402 km^2. An independent assessment made by the Forest Survey of India puts the area as 10,149 km^2 (FSI, 1989) for the period 1985-87. It indicates that the actual area under forests in Kerala is far below the area under forests by legal status.

The change in the area under forests including forest plantations in Kerala by legal status during the period 1956-57 to 1987-88 is shown in Figure 1 (see also Table 1). As can be seen in Figure 1, the area under forests has been more or less stable during the period 1956-57 to 1970-71. In the year 1971, private forests to an extent of 2270 km^2 were vested with the Government according to the Kerala Private Forests(Vesting and Assignment) Act 1971. It resulted in the sudden increase in the area under forests reported for 1971-72. Since then, the area under forests has been more or less stable, though there was some decrease during 1975-76 due to the change in the estimate of area under vested forests which was corrected later.

Table 1 Area under forests in Kerala

Year	Total forests (ha)	Plantations (ha)	Percentage under plantations (%)
1956	902810	32701	3.62
1957	902667	35918	3.98
1958	901564	39374	4.37
1959	901563	43282	4.80
1960	901578	47686	5.29
1961	901574	49769	5.52
1962	901570	52639	5.84
1963	900206	60019	6.67
1964	897720	66285	7.38
1965	901093	73524	8.16
1966	901849	79953	8.87
1967	901828	87763	9.73
1968	901827	94108	10.44
1969	901750	98485	10.92
1970	900883	101819	11.30
1971	1127849	104152	9.23
1972	1126677	108190	9.60
1973	1126659	118340	10.50
1974	1126464	123047	10.92
1975	1106820	126893	11.46
1976	1133464	129249	11.40
1977	1132024	131677	11.63
1978	1127065	136119	12.08
1979	1125087	140233	12.46
1980	1122912	143071	12.74
1981	1122640	147000	13.09
1982	1122307	149111	13.29
1983	1122249	151615	13.51
1984	1122243	151919	13.54
1985	1121824	155925	13.90
1986	1122320	159162	14.18
1987	1122520	154174	13.73

Source: Compiled from the administration reports of the Kerala Forest Department

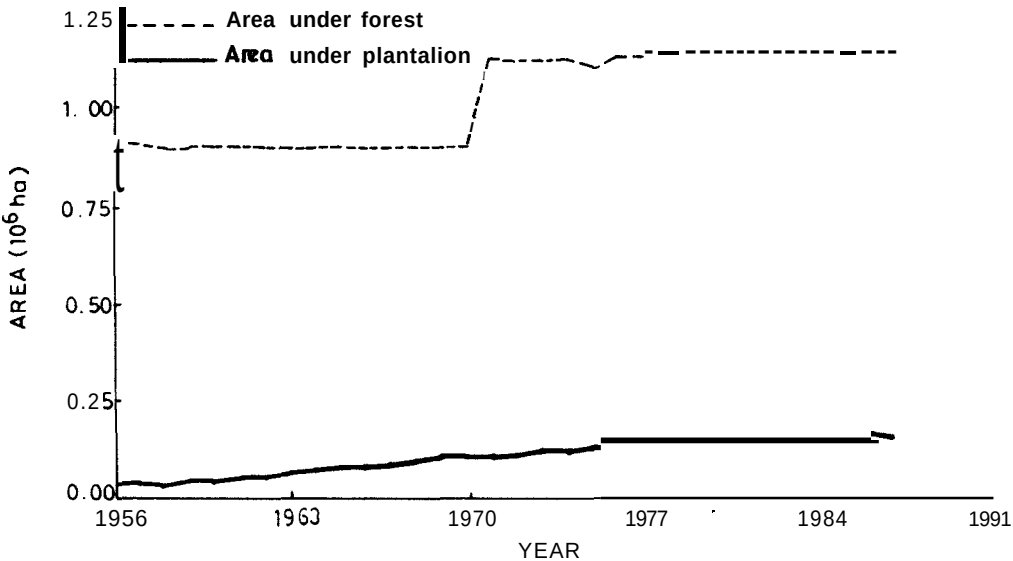

Fig. 1. **Area under forests in Kerala**

2.1.1 Area under plantations

The data on the growth of area under forest plantations in Kerala are presented in Figure 1 and Table 1. The area under plantations has been increasing at a compound rate of 5.18 percent per annum. The percentage of area under forest plantations to the total area under forests increased from 3.62 in 1956-57 to 13.73 in 1987-88.

The area under plantations of teak, eucalypts, softwood and other species (others include cashew, wattle, matty, albizia, balsa, bamboo, reed, etc. and exclude crops such as pepper, cocoa, medicinal plants, coffee, etc. underplanted in plantations) during the period 1956-57 to 1987-88 is presented in Table 2 (see also Table 3). From the above data it can be inferred that teak has been the main species until 1962. Since then, the area under eucalypt plantations increased very rapidly. The area under teak has also expanded during this period. The area under teak was growing at a compound rate of 3.11 percent per annum while the area under eucalypts was increasing at the rate of 20.16 percent per annum. The growth rates in the area under softwood and other species are 6.46 and 3.73 percent per annum respectively over the period 1956-57 to 1987-88.

Table 2 Area under plantations of different species in Kerala

Year	Teak (ha)	Softwood (ha)	Eucalypts (ha)	Others (ha)	Total (ha)
1956	26452	1836	108	4305	32701
1957	29063	2795	51	4009	35918
1958	29918	3140	153	6163	39374
1959	31457	4182	282	7361	43282
1960	33107	5566	317	8696	47686
1961	34186	6590	410	8583	49769
1962	35470	7612	521	9036	52639
1963	38860	8701	2820	9638	60019
1964	41771	10089	6058	8367	66285
1965	45050	11779	8527	8168	73524
1966	47569	12950	11475	7959	79953
1967	49377	14196	16488	7702	87763
1968	51207	15247	19715	7939	94108
1969	52156	16425	21951	7953	98485
1970	53483	16927	23232	8177	101819
1971	55557	16685	23439	8471	104152
1972	55758	17880	25701	8851	108190
1973	58623	18454	31557	9706	118340
1974	62044	19219	31565	10219	123047
1975	63824	20021	32645	10403	126893
1976	65470	20414	32241	11124	129249
1977	68511	21634	31051	10481	131677
1978	71439	21619	32687	10374	136119
1979	73930	22173	32816	11314	140233
1980	75038	22897	33181	11955	143071
1981	76587	23355	33758	13300	147000
1982	77479	23574	34252	13806	149111
1983	78283	23790	35129	14413	151615
1984	78452	22796	34330	16341	151919
1985	79596	23133	34806	15275	155925
1986	79416	23101	34728	18357	159162
1987	78583	10695	33987	30909	154174

Table 3. Percentage of area under plantations of different species in Kerala

Year	Teak	Softwood	Eucalypts	Others
	%	%	%	%
1956	80.89	5.62	0.33	13.16
1957	80.92	7.78	0.14	11.16
1958	75.98	7.97	0.39	15.65
1959	72.68	9.66	0.65	17.01
1960	69.43	11.67	0.67	18.24
1961	68.69	13.24	0.82	17.25
1962	67.38	14.46	0.99	17.17
1963	64.75	14.50	4.70	16.06
1964	63.02	15.22	9.14	12.62
1965	61.27	16.02	11.60	11.11
1966	59.50	16.20	14.35	9.96
1967	56.26	16.18	18.79	8.78
1968	54.41	16.20	20.95	8.44
1969	52.96	16.68	22.29	8.07
1970	52.53	16.62	22.82	8.03
1971	53.34	16.02	22.50	8.13
1972	51.54	16.53	23.75	8.18
1973	49.54	15.59	26.67	8.20
1974	50.42	15.62	25.65	8.30
1975	50.30	15.78	25.73	8.20
1976	50.65	15.79	24.95	8.61
1977	52.03	16.43	23.58	7.96
1978	52.48	15.88	24.01	7.62
1979	52.72	15.81	23.40	8.07
1980	52.45	16.00	23.19	8.36
1981	52.10	15.89	22.96	9.05
1982	51.96	15.81	22.97	9.26
1983	51.63	15.69	23.17	9.51
1984	51.64	15.01	22.60	10.76
1985	51.05	14.84	22.32	9.80
1986	49.90	14.51	21.82	11.53
1987	50.97	6.94	22.05	20.05

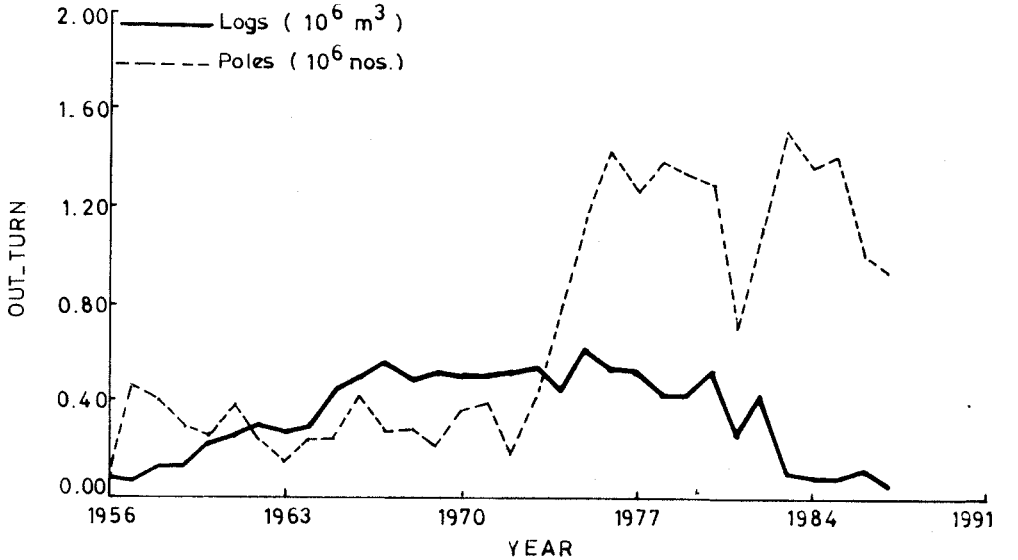

Fig.2. Out_turn of timber from forests in Kerala

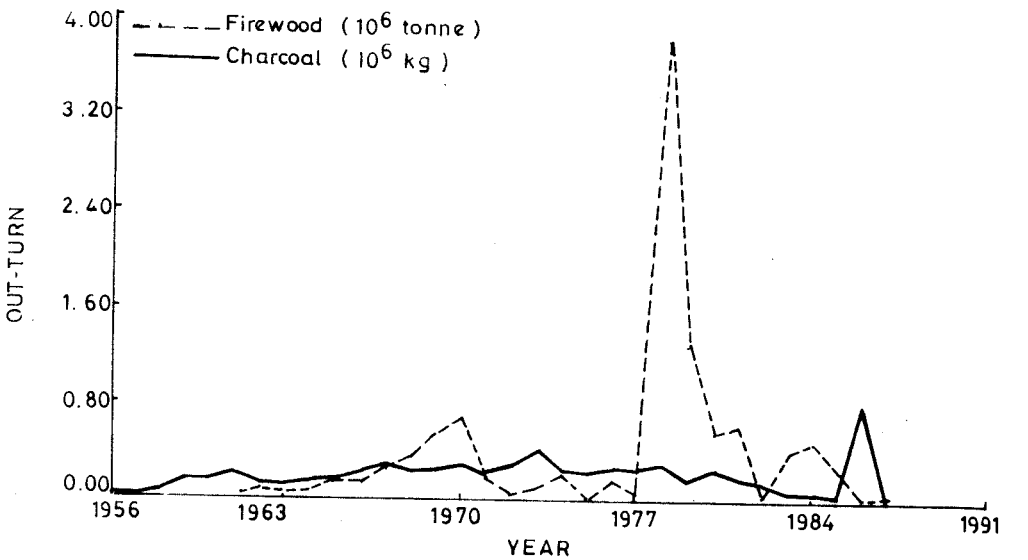

Fig. 3. Out-turn of charcoal and firewood from forests in Kerala

Table 4 Out-turn of timber, charcoal and firewood forests in Kerala

Year	Timber round logs (m^3)	Timber round poles (NO.)	charcol (kg)	firewood (tonne)
1956	88305	127237	0	42374
1957	73504	461563	0	24070
1958	126198	411290	0	52293
1959	123076	302414	0	166866
1960	223291	252349	0	179383
1961	238009	376650	0	193934
1962	287601	241399	72780	119775
1963	271601	152755	28420	84526
1964	284662	249881	**58690**	135404
1965	437677	251019	103172	163255
1966	504432	422985	123250	257160
1967	554163	279441	228600	313016
1968	482864	288543	322015	229734
1969	515417	211597	510991	251612
1970	498487	368081	643415	286207
1971	493711	394028	209924	193704
1972	**509400**	193718	**66360**	261341
1973	541466	414346	87863	414600
1974	452225	812959	204804	238476
1975	616062	1153065	12522	225043
1976	540643	1417501	148495	264577
1977	520924	1258052	58625	250837
1978	447091	1387450	3798275	*304683*
1979	434831	1344376	1266225	165528
1980	529758	1209790	554475	249028
1981	255866	696718	***605400***	187855
1982	419948	1102063	9275	141242
1983	111373	1512412	403326	68275
1984	82893	1364131	488073	57533
1985	81102	1404228	280586	31579
1986	107028	1007863	25650	784742
1987	51115	939709	18515	25437

Table 5 Revenue from forests in Kerala

Year	Total forest revenue (Rs)	Revenue from plantations (Rs)	Percentage of revenue from plantations
1956	22868218.50	1311876.00	5.74
1957	29079147.81	3420742.00	11.76
1958	31164514.81	2318234.00	7.44
1959	32988851.81	1834491.00	5.56
1960	43193881.80	3638521.00	8.42
1961	39250284.02	4210202.00	10.73
1962	48013193.03	4631868.00	9.65
1963	48377210.95	4262413.00	8.81
1964	52366035.60	6779154.00	12.95
1965	57044465.03	5345376.00	9.37
1966	66559511.95	1730616.00	2.60
1967	74426739.16	3304778.00	4.44
1968	82848740.63	4904094.00	5.92
1969	88288529.28	5462941.00	6.19
1970	91508990.00	4861582.00	5.31
1971	106111063.87	9834604.00	9.27
1972	104587586.70	10199458.00	9.75
1973	145364903.45	14932087.00	10.27
1974	181707190.20	12282409.00	6.76.
1975	219207006.47	11782500.71	5.38
1976	261774665.72	15177265.00	5.80
1977	317836228.61	15826042.08	4-98
1978	350619137.51	24174650.88	6.89
1979	440119783.68	28074285.00	6.38
1980	457286939.60	30888752.00	6.75
1981	519123293.12	42598998.00	8.21
1982	481762233.97	50502918.00	10.48
1983	405270000.00	57272274.00	14.13
1984	333640747.36	NA*	NA
1985	424450998.31	NA	NA
1986	481819996.63	NA	NA
1987	401942996.09	NA	NA

*Not available

Table 6 Expenditure on forests in Kerala

Year	Total expenditure on forests (Rs)	Plantation charges (Rs)	Percentage of expenditure on plantations
1956	6053901.55	207518.00	3.43
1957	7498296.66	288028.00	3.84
1958	8959118.60	358800.00	4.00
1959	10677261.85	499919.00	4.68
1960	11133573.77	367335.00	3.30
1961	12402006.46	599811.00	4.84
1962	14619056.15	617275.00	4.22
1963	15352963.69	2989043.00	19.47
1964	16784507.48	2940822.00	17.52
1965	21240540.17	3723230.00	17.53
1966	25698714.66	4879848.00	18.99
1967	28339769.30	4902931.00	17.30
1968	28454137.11	3894213.00	13.69
1969	31305899.75	2546128.00	8.13
1970	32260028.00	2926756.00	9.07
1971	35801570.11	2803304.00	7.83
1972	34375616.81	2432492.00	7.08
1973	43779251.66	3188561.00	7.28
1974	54729762.22	5628123.00	10.28
1975	73384066.30	6568404.95	8.95
1976	76922282.40	3784896.00	4,92
1977	76787824.00	4702784.34	6.12
1978	83452818.63	7150310.54	8.57
1979	93916930.30	9710545.00	10.34
1980	121619452.46	16244835.00	13.36
1981	152321165.13	19655090.09	12.90
1982	131171418.61	18000008.00	13.72
1983	160506398.24	23263328.00	14.49
1984	158026050.51	6938674.85	4.39
1985	238276999.45	5645767.00	2.37
1986	280750398.07	12225337.00	4.35
1987	262275496.19	8991469.00	3.43

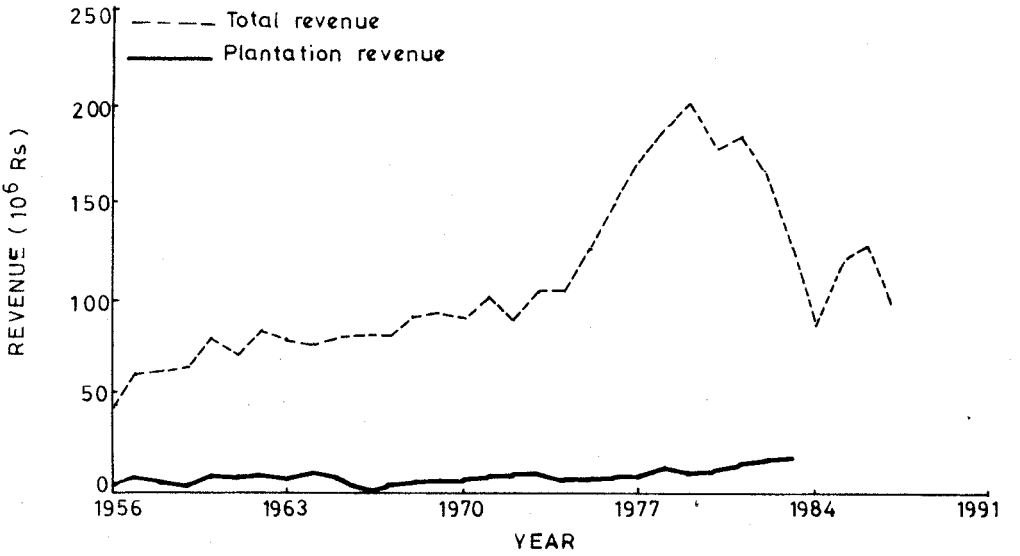

Fig. 4. Revenue from forests in Kerala at 1970-71 prices

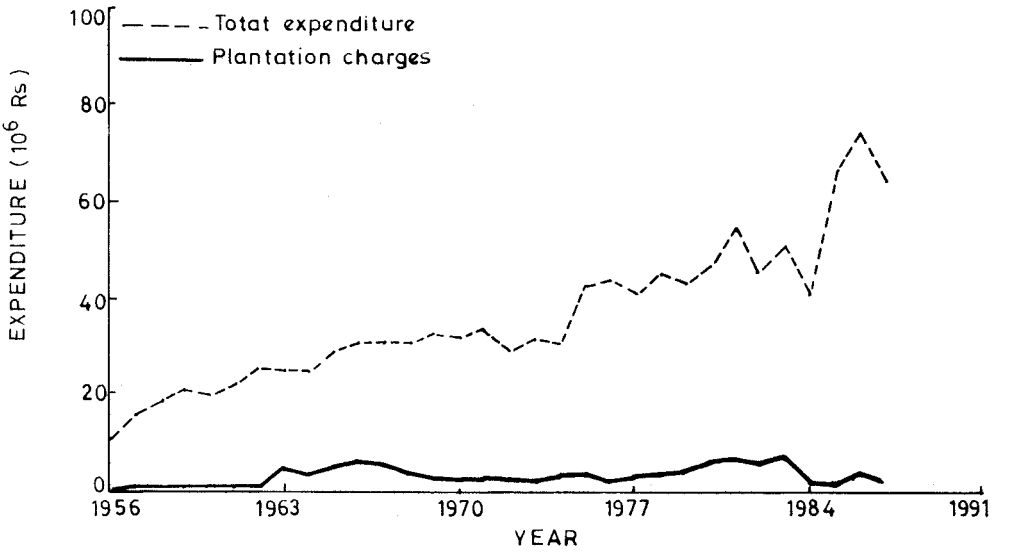

Fig. 5. Expenditure on forests in Kerala at 1970-71 prices

2.2 Production

Figure 2 shows the out-turn of timber in round logs and poles and Figure 3 presents the production of firewood and charcoal during the period 1956-57 to 1987-88 (see also Table 4). Timber in round logs was increasing till 1975 although there were year to year fluctuations. Production of timber in round poles has also shown ups and downs and considerable increase was noticed after 1974. The production of firewood was relatively high during 1973-74. Generally, the period 1965-1980 was characterised by increased out-turn of forest products. This was due to the fact that extensive forests were clearfelled during this period for forestry and non-forestry purposes.

2.3 Revenue and expenditure

The revenue from forests and the expenditure incurred for the period. 1956-57 to 1987-88 are given in Tables 5 and 6 respectively. The revenue and expenditure in real terms (at 1970-71 prices) are presented in Figures 4 and 5 respectively. The revenue was increasing till 1979-80 mainly due to the higher out-turn of forest products. Since then the revenue was declining due to the reduction in the production. The revenue from plantations was increasing at a

Table 7 Contribution of revenue from forests to the total revenue in Kerala

Year	Revenue from forests (Rs in million)	Total State revenue (Rs in million)	Contribution of forests to total State revenue (%)	Expenditure on forests as a percentage of revenue from forests (%)
1960	43.19	504.02	8.57	25.77
1965	57.04	821.00	6.95	37.24
1970	91.51	1507.93	6.07	35.25
1975	219.21	3515.54	6.24	33.47
1980	457.29	6403.80	7.14	26.60
1981	519.12	8504.80	6.10	29.34
1982	481.76	8102.00	5.95	27.23
1983	405.27	9342.60	4.34	39.61
1984	333.64	11249.90	2.97	47.37
1985	424.45	140552.30	3.02	56.14
1986	481.92	1502.30	3.21	58.27
1987	401.94	16484.70	2.44	65.25

marginal rate. The total expenditure in real terms shows a clear increasing trend. The expenditure on plantations also shows an increasing trend although there was slight decline after 1983-84. Contribution of forests to the total revenue in Kerala ranged from 8.57 percent in 1960 to 2.44 percent in 1987 and percentage of expenditure on forests to the forest revenue varied from 25.77 in 1960 to 65.25 in 1987 (Table 7).

3. A MANAGEMENT INFORMATION SYSTEM FOR PLANTATIONS (MISP) IN KERALA

Plantations are important components of the forestry sector in Kerala. While many policy decisions with regard to planting and felling are made at the. State level, routine management decisions are left to the Divisional level. A well organized information system will be a valuable tool for both long term and short term planning at both these levels. The prime requiremeht for developing such a system is a reliable data base. The retrieval system should be efficient and well adapted for answering the management questions. In most cases the goal will be to achieve sustained yield over years and the major decisions are concerning planting, thinning and harvesting. In particular these are area planted, thinning schedule and rotation age. The essential details required regarding plantations include location/name of the plantation, species planted, whether pure or mixed, ratio of mixing, extent and espacement. Some of the desirable information pertain to the site quality distribution, thinnings done, yield from thinning, year of coppicing, yield from coppice, stocking and other site details where applicable. Some efforts towards this end are elaborated below.

3.1 A computerized data base and retrieval system for plantations in Kerala

The details of the forest plantations in the State with respect to species, year of planting, area and location for the reference year 1987-88 were obtained from the Kerala Forest Department and the Kerala Forest Development Corporation. The data were utilized to form a computerized data base. A programme was written in dBASE III + which can retrieve the information pertaining to any set of plantations in the State instantly. The user can choose the administrative level like the State, Division or Range, specify the species group and year of planting and request for a complete listing or summary figures applicable to the level he has chosen. The advantages of having such a facility are many. Answers to the questions posed by the forest managers on the extent of area under a particular species qualifying for harvesting in the next few years, the set of plantations on which thinning operations are to be undertaken, the

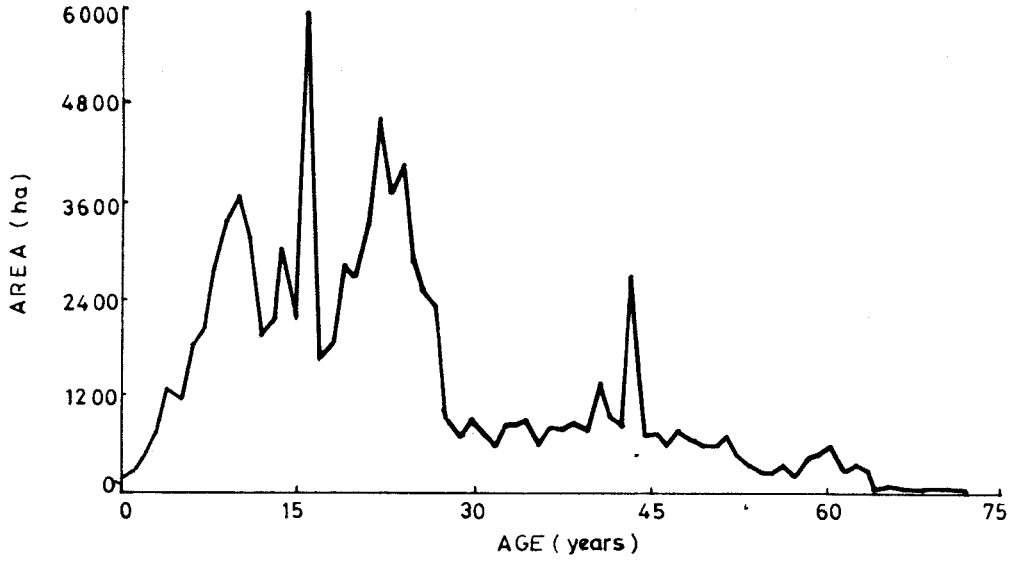

Fig. 6. Age class distribution of area under teak and mixed teak in 1987

Fig. 7. Age class distribution of area under eucalypts and mixed eucalypts in 1987

expected volume of harvest from such operations, etc. are obtained with ease. The age class distribution of area for any species group at a particular administrative level can be requested for and this helps in projecting future out-turn from plantations of that species group under a particular management strategy. The age class distribution of area at the State level worked out using MISP for 1987-88 for some important species groups are graphed in Figures 6 and **7.** The results of a simulation study using this data are reported in the next section.

3.2 Projection of out-turn from teak plantations in Kerala for a full rotation period

But for some stochastic elements the future out-turn from plantations is completely determined by the current age structure and the management policies adopted from time to time. The age class distribution of area under teak plantations in 1987-88 (Figure 6) formed the basis for projection. Data on stock mapping of teak plantations in Kerala, compiled from nine Working Plan Reports during the period 1954 to 1984 covering nearly 19,800 ha, revealed that 44 percent of the area belonged to site quality V and progressively lesser fractions in other classes. The mean top height worked out to be approximately **21** m which corresponded to site quality III of the yield tables for teak (FRI and Colleges, 1970)**.** Hence, the yield levels chosen for projection were that of site quality III of the above tables.

The thinning schedule adopted for projection is 4,8,12,18,28 and 40 years after planting. The selected rotation ages are 50,55 and 60 years. The area qualifying for different types of thinnings and final felling is computed every year and the corresponding yield is determined. The area felled every year is taken to be replanted next year with teak. The area under teak mixed with other crops is dealt with in two ways. First, all the area under mixed teak was added to the area under pure teak to provide an upper limit for yields. Secondly only **75** percent of the area under mixed teak was considered for computation of teak yields. This is to account for loss in the yield of teak due to replacement by and competition from other crops planted with teak. This is supposed to provide a lower limit for the expected yields. A pictorial representation of the expected yields under the three rotation ages is given in Figures **8** to **13.** The area under mixed teak continues to be planted in the same fashion after felling.

As can be seen from the Figures **8** to **13** the projection of yields is just a mirror image of the age class distribution of area given in Figure 6. Since most of the area under teak as of 1987 is below 30 years of age, they become available for harvest after 20,25 or 30 years from 1987 depending upon the rotation age. This fact is reflected in the final felling yields. Consecutive pairs of Figures like Figures 8 and 9,10 and 11, **12** and **13** provide the upper and lower limits as discussed above. The notations r, 100t, 75tm in these figures indicate rotation age, 100 percent of area under teak and 75 percent of area under teak mixed

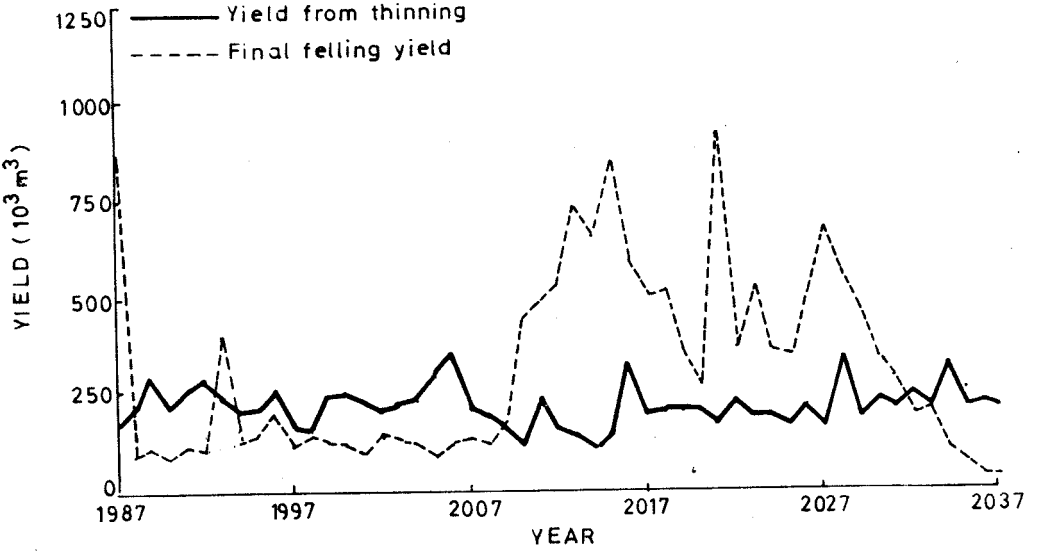

Fig. 8 . Projection of yield from teak plantations (r = 50,100t : 100tm)

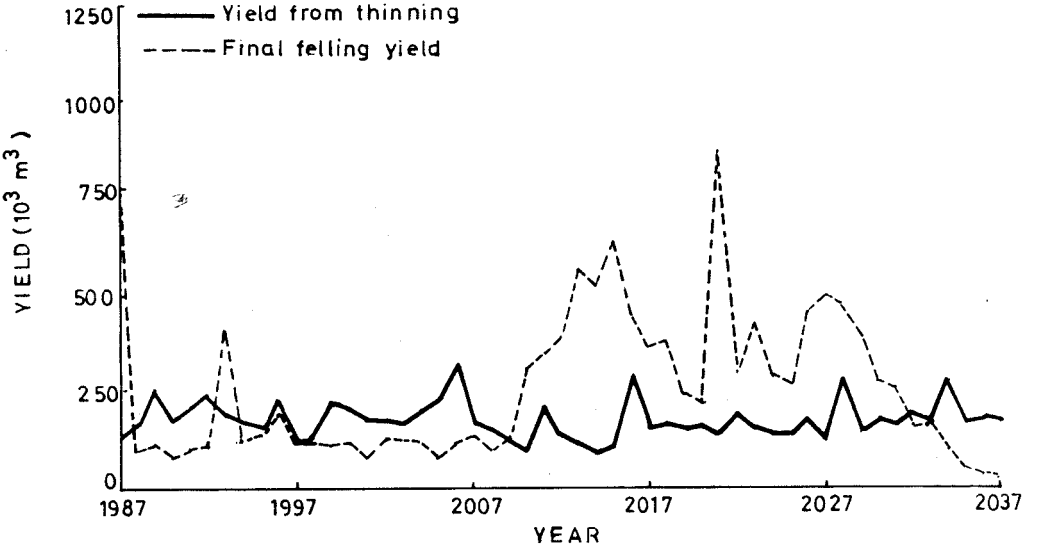

Fig. 9 . Projection of yield from teak plantations (r = 50,100t ; 75tm)

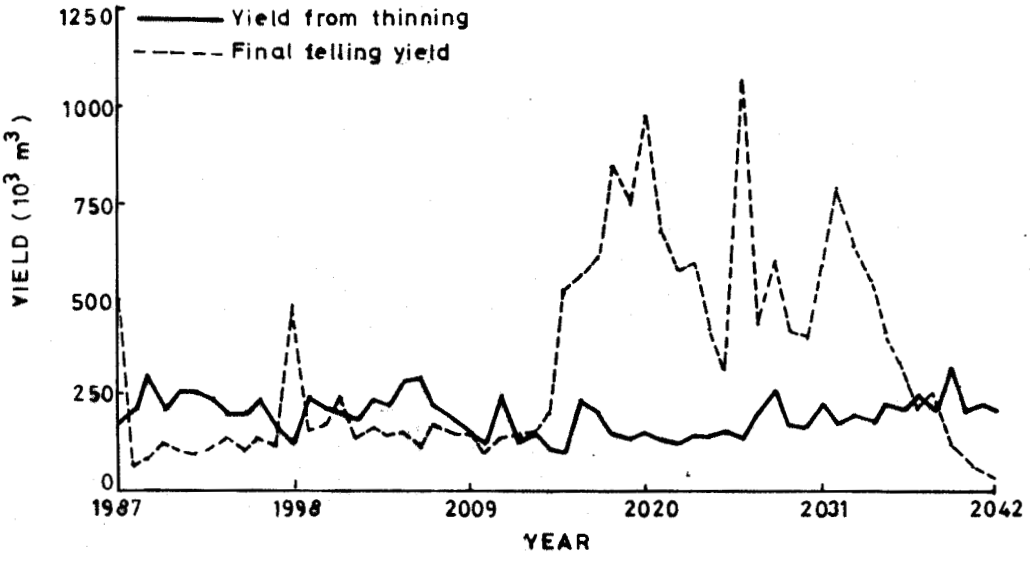

Fig. 10 Projection of yield from teak plantations (r = 55,100t : 100tm)

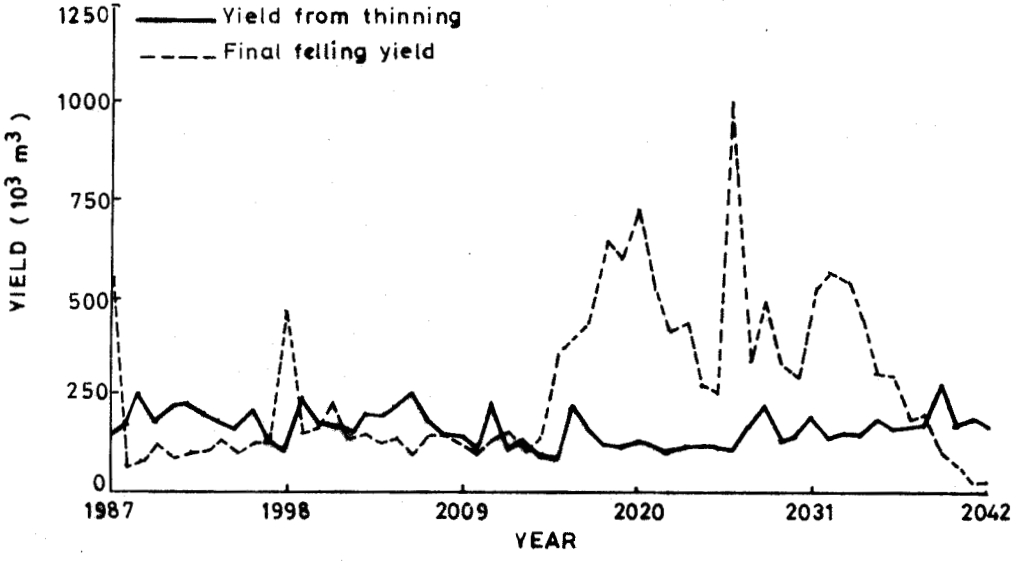

Fig. 11. Projection of yield from teak plantations (r = 55,100t : 75tm)

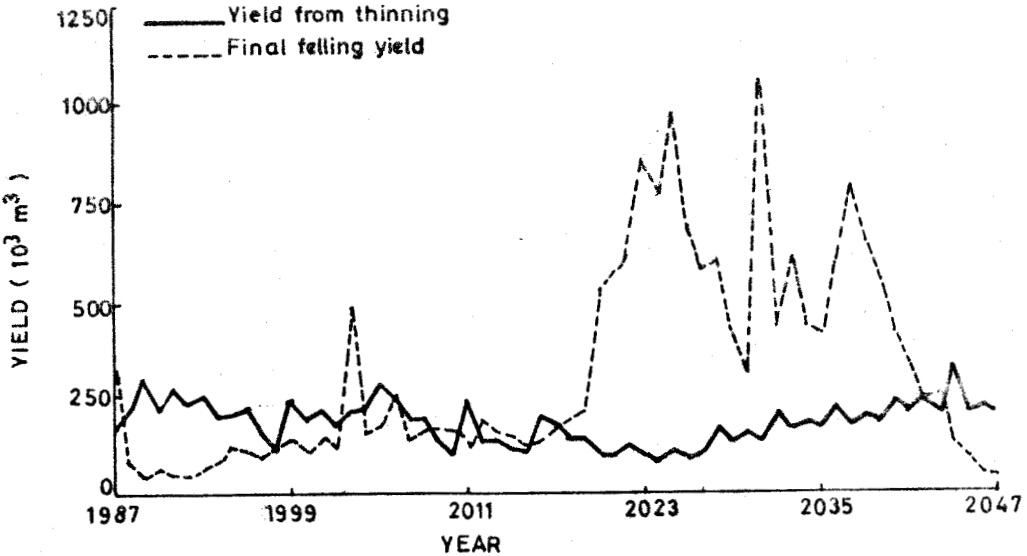

Fig. 12 Projection of yield from teak plantations (r = 60,100t : 100tm)

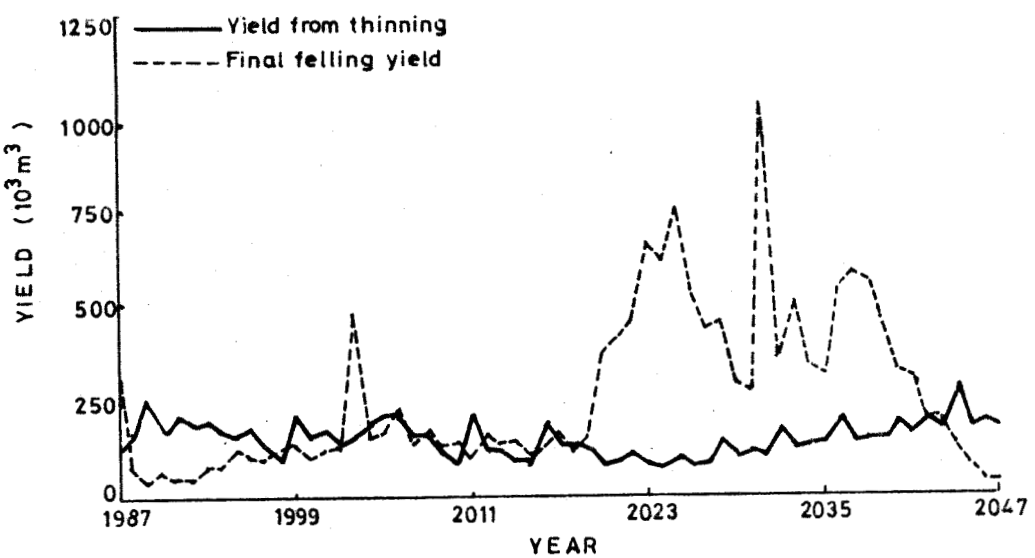

Fig. 13. Projection of yield from teak plantations (r = 60,100t : 75tm)

with other species respectively. The starting yield in 1987 is high because all the plantations which have reached or crossed the rotation age are assumed to be felled in that year. But for the starting point, these patterns are supposed to recur if there are no changes in the planting policy. Saving the excess for lean periods will be a sensible policy to achieve sustained yields. The thinning yields which constitute mostly of pole crop and small timber are more or less stabilized because thinning schedule is spread out in different years. It must be remembered that the yield levels presented are potential yield levels based on fully stocked stands as per the yield tables and could differ from that actually realized in the field. However, the major trends shall remain the same.

4. A STUDY ON YIELD FROM EUCALYPT PLANTATIONS IN KERALA

Large scale planting of eucalypts was initiated in Kerala by the Forest Department in the late 1950's. At the end of 1987 an area of 44,108 ha has been under eucalypts in Kerala. The eucalypt wood obtained from plantations is utilized by the pulp and paper industries which are crucially dependent on the availability of the material. With the present scarcity of raw materials for the industries, an evaluation of the yield potential of plantations in Kerala is of importance. The existing yield tables (Pande, 1978, Sharma, 1978) can indicate the expected yield under a particular site quality and stand density in the field. But they cannot answer questions on the yield levels obtained from the plantations in Kerala unless information on site quality and stand density are available for individual plantations. The following study was planned to obtain information on the levels of yield that are realized under the actual growing conditions in the field and to study the effect of some of the factors that may cause variation in these levels.

4.1 Data and mode of analysis

Data on first rotation yield from plantations at the time of felling were gathered from records kept at the different Forest Range Offices in Kerala. There were 173 plantations which differed with respect to age at harvest and espacement and belonged to Wynad, Kozhikode, Trichur, Vazhachal, Munnar, Pamba, Punalur, Thenmala and Trivandrum Forest Divisions. Records on yields of *Eucalyptus tereticornis* were available for 111 plantations mostly from low elevation areas and of *E. grandis* from *62* plantations mostly from high elevation areas. The area of individual plantations varied from 2.63 to 197.48 ha. The data were subjected to an analysis of covariance (ANACOV). Species and Divisions served as factors. Age at harvest, number of trees planted, area of

Table 8 Analysis of variance of yield from eucalypt plantations

Source	Degrees of freedom	Mean Square	F-value
Rotation age	1	160279.2	25.23*
No. of trees planted	1	9139.8	1.50
Area	1	39675.3	6.49*
(Rotation age)^2	1	246508.3	40.34*
(No of trees planted)^2	1	8921.0	1.46
(Area)^2	1	10499.2	1.72
Species	1	34527.6	5.65*
Divisions	1	10518.8	1.72
Residual	157	6110.0	

* *Significant at P = 0.05*

Table 9 Mean Yield at the different rotation ages for the two species

Species	Rotation Age (Years)	Yield (m^3 ha^{-1}) Mean	SD*	No. of trees planted (No ha^{-1}) Mean	SD	No of cases
E. tereticornis	10	72.59	46.00	1367	479	56
	11	78.05	35.03	1115	290	26
E.grandis	10	137.64	76.62	1308	440	12
	19	193.50	95.70	905	55	16

* SD = Standard deviation

the plantations and their corresponding squared terms were taken as covariates. Covariates were included first in the model followed by factors. Effect of each covariate was adjusted for the effects of other covariates whereas effect of each factor was adjusted for the effects of other factors and all the covariates.

4.2 Results and discussion

ANACOV indicated that differences in yield are mainly attributable to the differences in the species, rotation age and size of the plantations. Rotation age had a quadratic effect on yields. The results are given in Table 8. A large part of the variation remained unexplained as the model R^2 was 0.60. This is attributable to the differences in the site productivity and variation in the stocking at the time of felling caused by fire, diseases and illicit felling.

Table 9 gives the mean yield (stacked volume under bark) at different ages for the two species. Only those cases where the number of plantations is above 10 are reported here. Unweighted means were computed *so* as to give equal importance to the productivity estimates from every plantation regardless of their sizes. Otherwise the average would get biased towards any particular condition. The average of the number of trees planted is also given along side. The yield could not be adjusted for variation in espacement as these two were found uncorrelated. Attempts to predict yield from rotation age and number of trees planted did not meet with success as the R^2 values were low due to high variation between sites. The ranges of yield and number of trees planted in individual plantations are given in Table 10.

Table 10.. Range of yield and number of trees planted fc the two species at selected ages

Species	Rotation age (Years)	Yield (m^3 ha^{-1}) Min	Max	Trees planted (No. ha^{-1}) -Min	Max
E.tereticornis	10	1.708	209.548	1075	2500
	11	3.834	143.030	891	2500
E. grandis	10	38.690	284.303	891	2500
	19	67.280	380.960	891	1111

The mean yield of *E. grandis* is better than that of *E. tereticornis*, but the prominent feature is the large variation observed within each species due to the reasons mentioned above. These yields are not directly comparable with the figures in yield tables as it requires knowledge of the stand density at the time of felling. However, the figures represent the average yields that are actually realizable in the field for the two species at the specified rotation ages. Using a factor of 0.71 for conversion to solid wood the mean annual increment at 10 years works out to be 5.15 m^3 ha^{-1} for *E. tereticornis* and 9.77m^3 ha^{-1} for grandis. In spite of the large variation in the original espacement, the effect of this factor did not turn out significant in the ANACOV and we may infer that proportional numbers of stems are not maintained at the time of felling. Similarly, large variation in yields within the Divisions had made the differences between the Divisions appear nonsignificant. Surprisingly, size of the plantations had a significant effect and a multiple linear regression run for each of the species . showed a negative sign for the corresponding partial regression coefficients.

5. REGIONAL VARIATION IN RAINFALL IN KERALA

While high rainfall is generally beneficial to forest growth it plays havoc in open and degraded forests, especially in steep slopes. Mean annual rainfall is a fair indicator of the production potential of a place and has other ecological implications like species occurrence, phenology, etc. Some available data gathered on rainfall are presented here and certain inferences drawn are detailed.

5.1 Data and mode of analysis

Data on rainfall recorded in different rainguaging stations distributed over several catchments were obtained from the Kerala State Electricity Board. The number of years for which records were available ranged from 4 to 49 years. The catchment-wise mean annual rainfall is given in Table 11. The highest mean annual rainfall (5900 mm) was received in Rajamala catchment of Periyar riverbasin whereas the lowest (1323 mm) came from Pamba catchment of Pamba riverbasin. The mean annual rainfal of individual stations ranged from 1062 to 6774 mm. These belonged to Pamba and Mananthoddy catchment respectively.

One-way analysis of variance (ANOVA) was conducted to find out if the catchments differed significantly with respect to mean annual rainfall. This was followed by a comparison of the means through Duncan's Multiple Range Test (DMRT).

Table 11 Mean annual rainfall in different catchments in Kerala

Catchment no.	Riverbasin	Catchment	Mean annual rainfall (mm)	No. of stations *
1	Achencoil	Achencoil	2467.35	4
2	Bharathapuzha	Kerala Bhavani	2823.09	6
3	Bharatha uzha	Silent valley	4465.37	1
4	Chalakud)y	Karapara	3510.21	11
5	Chalakudy	Kerala Sholayar	4260.27	8
6	Chalakudy	Kuriankutty	2268.24	6
7	Chalakudy	Outside Scheme	3111.49	3
8	Chalakudy	Parambikulam	2080.89	6
9	Chalakudy	Peringalkuth	3662.91	2
10	Chalakudy	Pullickalar	4331.03	1
11	Chalakudy	T N Sholayar	3397.04	18
12	Chaliyar	Chalipuzha	3577.34	13
13	Chaliyar	Cholattipuzha	2324.57	11
14	Chaliyar	Punnapuzha	2490.88	12
15	Kaveri	Kuttiadi augmen	5511.63	1
16	Kaveri	Manathavady	4662.02	10
17	Kuttiadi	Kuttiadi PH	5880.15	2
18	Pamba	Kakkad Scheme	3203.39	6
19	Pamba	Iravikulam	2634.17	3
20	Pamba	Pamba	1323.07	3
21	Periyar	Anamalai	5071.11	1
22	Periyar	Anayerumkad	2343.06	3
23	Periyar	Bison valley	2667.70	2
24	Periyar	Chemmanar	2136.85	8
25	Periyar	Eastern Kallar	2078.94	12
26	Periyar	Edamalayar	4684.94	2
27	Periyar	Erattayar	1959.19	4
28	Periyar	Idukki	3115.47	12
29	Periyar	Karinthuri	5418.95	1
30	Periyar	Kundale	1581.08	3
31	Periyar	Lower Periyar	3813.45	7
32	Periyar	Madupetty	2188.21	5
33	Periyar	Manali	5036.41	1
34	Periyar	Mankulam	4906.69	1
35	Periyar	Muthirapuzha	2805.43	6
36	Periyar	Outside-scheme	4382.68	1
37	Periyar	Panniar	2040.85	7
38	Periyar	Perinjankutty	2683.41	5
39	Periyar	Ponmudi	2288.14	2
40	Periyar	Pooyamkutty	4866.86	1
41	Periyar	RAH Works	3493.83	13
42	Periyar	Rajakad	2305.04	3
43	Periyar	Rajamala	5900.70	2
44	Periyar	Thottiar	4754.46	1
45	Periyar	Thuvellar	2358.88	2
46	Periyar	Upper Kallar	5643.99	2
47	Periyar	Western Kallar	3521.23	2

* Indicates the number of rain gauging stations in each catchment

5.2 Results and discussion

ANOVA showed significant differences among the catchments giving an F value of 10.63 at 46 and 189 degrees of freedom. In general the catchments numbered 3, 15, 16, 17, 21, 26, 29, 33, 34, 40, 43, 44 and 46 belonged to the highest group within which the differences were not significant (Table 11). The catchments numbered 1, 6, 8, 13, 14, 19, 20, 22, 23, 24, 25, 27, 30, 32, 35, 37, 38, 39, 42 and 45 formed a lower set with statistically nondiffering mean values.

6. ATTEMPTS ON FORECASTING TIMBER PRICES IN KERALA

In the case of timber, price forecasts are essentially useful for price regulation through governmental measures. In the recent past, timber prices have registered a phenomenal rise (Krishnankutty *et a/.*, 1985) and it is worthwhile investigating whether this will continue in the coming years. An attempt was made here to see if reliable forecasts can be made through statistical procedures alone.

6.1 Data and mode of analysis

The data used were that reported by Krishnankutty *et a/.* (1985) for the eight species updated to 1984-85. The different species were anjily *(Artocarpus hirsutus),* chadachy *(Grewia tiliifolia),* irul *(Xylia xylocarpa),* pullamaruthu *(Terminalia paniculata),* thekku *(Tectona grandis),* thembavu *(Terminalia crenulata),* venga *(Pterocarpus marsupium)* and venthekku *(Lagerstroemia microcarpa).* The data on prices for the period 1956-57 to 1974-75 were obtained from the Forest Working Plans and for the rest of the years from auction registers maintained in the forest depots. The average State level prices worked out were deflated using Wholesale Price Indices for all commodities taking 1970-71 as the base year (index = 100). Data on disposal of timber from the forest depots for the corresponding years were obtained from the Administration Reports of the Forest Department.

Firstly the figures for the last three years of the series were kept separate for validation of the forecasts. A simple mean- range plot of prices indicated the need for a multiplicative model and accordingly the prices were converted to the log scale. The trend component was eliminated from both the series on price and disposal by first order differencing. Lagged values of the detrended series up to four years of lag were generated and used as regressors in the stepwise regression taking current price difference in the log scale as regressand.

6.2 Results and discussion

The results showed that lagged relations existed only for three species as reported in Table 12. Even for the species which showed some relation, the R^2 values were not high enough to undertake any prediction. The regression coefficients have the right sign indicating that a decline in the past supply would bring up the current price. Krishnankutty et al. (1985) had argued that the price levels are also affected by the demand made on the products and the expected price for the future years. As no information is available on these aspects the extent of this relation could not be investigated.

Since the results of stepwise regression showed weak relations, forecasting based on exponential smoothing (Chatrield, 1980) was attempted as an alternative. The method essentially amounts to expressing the current values as a weighted sum of previous values in the series, the weights taken in a geometric progression with a constant ratio $(1- \alpha)$. The parameter a was estimated by minimizing the residual sum of squares and one step ahead forecasts were generated. Kendall (1973) has indicated that such forecasts can be used for projection for more than a single year. The forecasts were compared with the actual values for the last three years of the series and the deviations obtained are reported in Table 13. The maximum percentage deviation varied from 5.10 to 37.28 over the different species which in general does not seem to be very satisfactory. The method in particular seems to be underpredicting the prices.

The above study revealed that the prices are subject to the influence of more factors other than those included in the present analysis and reliable forecasts are difficult to make unless information on those excluded factors become available.

7. CONCLUSIONS

Management of forests at any level involves both technical and administrative issues. The smooth functioning of the system rests largely on the availability of a reliable data base. Generating the data on the system should form the part of the system functioning itself. The present study has shown that such data can be utilized to produce valuable information which will be of use in the optimal management of the system. For instance, the management information system developed for plantations has enabled us to predict the future out-turn from teak plantations in Kerala under certain management policies. Similar systems can be thought of in the case of natural forests as well which

Table 12 Results of stepwise regression using lagged variables

Species	Regression coefficients		R^2
	wdt1	wdt2	
Pullamaruthu	-0.0068	-0.0053	0.4911
	(0.0020)	(0.0020)	
Thekku	-0.0107		0.4287
	(0.0028)		
Thembavu	-0.0119		0.3120
	(0.0041)		

Note: Figures in parentheses indicate standard errors. wdtl, wdt2 indicate lagged values of disposal. after detrending.

Table 13 Comparison of forecasts with the actual price levels

Species	Value of a for exponential smoothing	Forecast errors* in different lead years (%)		
		one *step*	two *steps*	*three steps*
Anjily	0.2	16.71	1.98	—14.26
Chadachy	0.1	5.10	0.76	0.45
Irul	0.1	31.41	23.51	36.76
Pullamaruthu	0.1	37.28	31.76	32.16
Thekku	0.2	21.64	-13.55	—12.89
Thembavu	0.2	22.11	13.71	9.70
Venga	0.1	25.39	15.59	5.55
Venthekku	0.1	28.02	31.67	32.27

* *Forecast error = (Actual - predicted)/ actual*

may be linked to a geodgraphical information system. When geographical units like blocks or compartments are identified and their status monitored over time it would throw in valuable information needed for the management of these units.

It is interesting to note that the forests contributed only around 3 percent of the total state revenue during the five years from 1983 and nearly **53** percent of the revenue earned was spent back on forest; but then the role of forests is not to be judged merely by such balance-sheets.