KFRI Research Report No. 255

A DATABASE ON FOREST RESOURCES OF KERALA
(Final Report of Project No. KFRI 357/2000)

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ABSTRACT OF PROJECT PROPOSAL

1. Project number	: KFRI 357/2000
2. Title of the Project	: A Database on Forest Resources of Kerala
3. Objectives	: (1) To develop a computerized database and information retrieval system on selected aspects of forest resources of Kerala (2) To extract information useful to the management of forest resources in the State based on statistical analysis
4. Date of commencement	: April 2000
5. Scheduled date of completion	: September 2001
6. Funding agency	: Science, Technology and Environment Committee, Government of Kerala
7. Investigator	: M.Sivaram

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KERALA AND ITS FORESTS: A STATISTICAL GLANCE

1.	Total geographic area of the State	**38,863 km^2**
2.	Location of the State	
	Latitude	**Between 8^0 18' and 12^0 48' N**
	Longitude	**Between 74^0 52' and 77^0 22' E**
3.	a. Total population of the State (2001)	**3,18,38,619**
	b. Density (No. of persons / km^2) (2001)	**819**
	c. Sex ratio (females per 1000 males) (2001)	**1,058**
	d. Percent urban population to total population (2001)	**25.97**
	e. Scheduled tribe population (1991)	**3,20,967**
	f. Scheduled caste population (1991)	**28,86,522**
	g. Tribal population inside forests	**73,492**
4.	State level literacy rate (2001)	**90.9**
5.	Per capita land (based on Census 2001)	**0.122 ha**
6.	a. Total forest area (2000)	**11,124 km^2**
	b. Per capita forest land (based on Census 2001)	**0.035 ha**
	c. Effective forest area	**9,400 km^2**
	d. Reserved forest area	**9,152 km^2**
	e. Reserved land	**182 km^2**
	f. Vested forest area	**1,893 km^2**
	g. Tropical wet evergreen and semi-evergreen	**3,299 km^2**
	h. Tropical moist deciduous	**4,100 km^2**
	i. Tropical dry deciduous	**100 km^2**

	j. Montane subtropical temperate shoals	**70 km^2**	
	k. Plantations	**1,791 km^2**	
	Teak – **75,883 ha**	Mahagony- **81 ha**	
	Rose wood- 414 ha	Sandal wood – **73 ha**	
	Eucalyptus – **24,458 ha**	Bamboo – **2,658 ha**	
	Cane – **995 ha**	Reeds – **525 ha**	
	l. Grasslands	**40 km^2**	
	m. Extent of Wildlife/Bird Sanctuaries and National Parks (Protected forest area)	**2,325 km^2**	
7.	a. Number of Wildlife Sanctuaries	**11**	
	b. Number of Bird Sanctuaries	**1**	
	c. Number of National Parks	**2**	
8.	Income of the State at current prices (Rs. in lakhs)		
	1. Gross income (1998-99) (P)	**56,43,919**	
	2. Net income (1998-99) (P)	**51,16,783**	
	3. Gross income (1997-98)	**49,48,447**	
	4. Net income (1996-97)	**44,88,347**	
9.	Per capita income of the State at current prices (Rs.)	**1997-98**	**1998-99 (P)**
	1. Gross	**15,690**	**17,716**

	2. Net	**14,231**	**16,062**
10.	Income from forestry and logging sector at current prices (Rs. in lakhs)	**1997-98**	**1998-99 (P)**
	1. Gross	**98,529**	**1,01,573**
	2. Net	**97,894**	**1,00,954**
11.	Total revenue of the State (Rs. in lakhs)		
	1. 1998-99	**7,20,059**	
	2. 1999-00	**7,94,381**	
12.	Revenue from forest (Rs. in lakhs)		
	1. 1998-99	**12,103**	
	2. 1999-00	**11,327**	

Source: 1. Census of India- 2001. Kerala. Series 33. Paper 1,2 and 3 of 2001, Provisional Population Totals. Directorate of Census, Thiruvananthapuram.

2. Forest Statistics –2000. Kerala Forest and Wildlife Department, Thiruvananthapuram.

Abstract

In this study, a computerized database and retrieval software, containing data collected from several secondary sources on selected aspects of forest resources of Kerala has been developed. The data presented in the software have also been analyzed to bring out useful information for forest management.

The sources referred for developing the database included the publications of the Kerala Forest Department (KFD), Ministry of Environment and Forests, Food and Agriculture Organization, Center for Science and Environment, Department of Statistics and Economics, Directorate of Census Operations, State Forest Departments and the Kerala Forest Research Institute and the articles published in journals.

The topics covered in the database include forest area, forest plantations, biodiversity, forest weather and revenue and expenditure of the Kerala Forest Department. The data on many of the aspects were of time-series type covering the period 1980 to 2000.

The database and retrieval software has been developed using the program 'Visual Fox Pro 6.0'. It is a down-loadable software from CD to the user's computer. The required data of interest can easily be retrieved in a few clicks. A glossary and the sources of the data are also provided.

Some of the salient features of the data presented in the software and their analysis are indicated below. The data used for the analysis were from several secondary sources and there were data limitations in terms of accuracy and sufficiency. Therefore, the analyses carried out are exploratory and inferences drawn may have to be used with due consideration of limitations.

The total land area of the State is 38,863 km^2, which is 1.2 per cent of the total land area of India. According to Population Census-2001, Kerala has a population of 3.2 crore which constitutes 3.4 per cent of the total population of the country. In terms of population density, Kerala has the highest density of 819 persons per km^2. The Western Ghats, its major portion in Kerala, is one of the 24 global hotspots of biodiversity. According to the Forest Survey of India 1997, the total recorded forest area in India was 7.65 lakh km^2. Out of this, forests in Kerala constituted 1.5 per cent. According to the Kerala Forest Department, the total forest area in Kerala as on year

2000 was 11,124 km^2. Of which, 82 per cent was declared as reserved forests and 16 per cent was declared as vested forests. The effective forest area in Kerala was 9,400 km^2, which is 85 per cent of the total forest area. Among the major forest types in Kerala, moist deciduous forests occupied 44 per cent, tropical wet evergreen and semi-evergreen occupied 35 per cent and plantations contributed to the extent of 19 per cent of the effective forest area. The extent of forest types of dry deciduous and montane sub-tropical temperate sholas and grasslands is only of negligible proportion. The area under protected forests was 21 per cent of the total forest area. A total of 10,035 plant species has so far been reported in Kerala. Out of these, 4,527 were flowering plants. The number of NWFP plant species was 550. With regard to animal diversity, the minimum number of species / genera, according to each animal group, is reported. According to the Forest survey of India 1995, the growing stock of Kerala forests was 9.89 crore m^3 and volume per ha was 95.67 m^3. The annual increment was 20 lakh m^3.

The district level annual deforestation rate in Kerala for the period 1961 to 1988 was examined in relation to population density, literacy rate, livestock density, land use pattern and per capita demand and production of wood using correlation and regression techniques. In multiple regression analysis, the differential literacy alone emerged significant explaining as much as 50 per cent variance in the annual deforestation rate, in contrast to our general expectation that the increase in deforestation was found in districts having lower level of literacy.

Teak and eucalypt have been the principal forest plantation species in Kerala. During the year 1999-2000, the total area under forest plantations was 16 per cent of the total forest area of 11,124 km^2. The area under teak plantations was exponentially increasing till 1980 and thereafter remained constant up to the year 2000 although the total area under plantations of all the species increased by 25 per cent over the last 20 years (1980-2000). During the year 1999-2000, the area under teak plantations was 75,885 ha, which constituted about 42 per cent of the total area under plantations. Seventy eight per cent of the area under teak plantations belonged to the territorial divisions and 22 per cent under the purview of protected area management. The teak plantations that come under the territorial divisions covered all age groups ranging from 0-4 years to 59 years and above and nearly 60 per cent of them was found in the

age group of 20-40 years. As regards teak plantations in the wildlife divisions, they were mostly found in the age group of above 15 years.

The extent of eucalypt plantations was 24,461 ha, which is 14 per cent of the total area under plantations. Out of these, 68 per cent was in territorial divisions and the remaining 32 per cent in wildlife divisions. The age structure of the existing eucalypt plantations that come under the KFD shows that more than 80 per cent of the total area under plantations crossed the rotation age of 8 years and 56 per cent was found in the age group of 25 years and above.

A comparison of available productivity figures of teak and eucalypt plantations reveals that the realized productivity was far below the potential productivity. The trends in the timber production from forests show that teak wood has been the most important timber in Kerala. For example, during the year 1999-2000, out of the total wood produced from forests, 96 per cent was teak wood. Among the 'soft wood' species, eucalypt constituted the major portion of supply and the whole supply used to be diverted to the Hindustan Newsprint Limited.

The future availability of teak wood from forest plantations up to the year 2050 has been projected under different scenarios, taking into account the factors such as age structure, rotation age, productivity and planting rates. The future trends in the availability of teak wood indicate that the period from the year 2010 to 2040 will have relatively higher availability of teak wood than the other time periods.

During the period 1999-2000, the net revenue of the Kerala Forest Department constituted nearly 1.5 per cent of the total revenue of the state government. The major source of the revenue was from the sale of timber.

The data on other aspects viz., timber prices and forest weather are presented. The gaps in the database developed and the issues and challenges related to developing comprehensive database on forest resources of Kerala have also been discussed.

1. Introduction

Data on forest resources and related aspects are vital for effective forest sector planning and management. A number of agencies such as State Forest Departments, Forest Survey of India, Ministry of Environment and Forests (Government of India), etc. have been publishing data on various aspects of forest. However, there have not been efforts to integrate these data and produce as computerized database for easy retrieval and reference. It has often been recommended that statistics of forestry should be brought together in a centralized system covering all aspects. Many experts have compared it to a river system, which is fed by tributaries drawing water sources of glaciers, surface run off and underground resources, etc. This system eventually feeds the ocean. As far as the State of Kerala is concerned there were some efforts by Jayaraman and Krishnankutty (1990), 15 years before. Recently, Subsequently In the present study, an attempt has been made to develop an integrated computerized database and retrieval software on selected aspects of forest resources of Kerala utilizing the data collected from several secondary sources and analyze the data on certain aspects to bring out useful information for forest management.

2. Computerized database and retrieval system

2.1 Sources of data

The database was developed by collecting data from several secondary sources and by communicating with various agencies. The sources include the publications of the Kerala Forest Department, Ministry of Environment and Forests, Food and Agriculture Organization, Center for Science and Environment, Department of Statistics and Economics, Directorate of Census, State Forest Departments and the Kerala Forest Research Institute and the articles published in journals. The details of the sources of the data are indicated under the section ‘References’.

2.2 Database

The database was developed keeping in mind mainly the general data requirements of the personnel involved in forestry and related disciplines. It may be noted that the data on certain themes are provided at the national and global level depending upon the data availability. The data on many of the aspects are of time-series type covering the period 1980 to 2000.

The database was developed on the following themes.

i) A Statistical Glance at Kerala and its Forests

Summary statistics on important features of Kerala such as geographical area, latitude and longitude, population, forest area under different vegetation types, species-wise area under forest plantations and information on revenue and expenditure.

ii) Forest Administration

Forest administrative units, forest stations, forest check posts and forest timber depots.

iii) Forest Area

Trends in forest area with respect to legal status, vegetation type. Forest area according to administrative units: range, division and district. Protected forest area, some details on deforestation in Kerala.

iv) Biodiversity

Plant and animal biodiversity, estimated population of major mammals in the forests.

v) Forest Plantations

Trends in area under plantation. Species-wise and division-wise list of forest plantations. Productivity of forest plantations for selected species. Expenditure due to forest plantations.

vi) Forest Products

Trends in the production of forest products including non-wood forest products. Timber price trends of selected species.

vii) Weather

Weather data from selected forest divisions and wildlife sanctuaries.

viii) Forest Fire

Number of incidents, area destroyed and financial loss.

ix) Revenue and Expenditure of the Kerala Forest Department

Statement of revenue and expenditure, sector-wise expenditure, revenue from forest products.

x) Other useful data

Demographic information

State-wise population and literacy rate. District-wise population and literacy rate of Kerala

Forest area

State-wise forest area by legal status and by forest cover type,

Forest Plantation

Productivity of forest plantations in tropical and sub-tropical regions.

Weather

Weather data from IMD centers.

2.3 Development of computerized database and retrieval system

The database software was developed using the computer program Visual Fox Pro 6.0. The data available in the database can be downloaded using the installation procedure presented in Section 2.4. The required data can be retrieved in two or three clicks. A few sample pages of the software are presented herewith to have an idea about the software. The first page displays the Main Menu showing the topics on which the data are available. The required data are obtained by clicking on the appropriate topics. For examples, the extent of forest area according to forest administrative units can be obtained by clicking on the *Spatial Distribution* given under the topic 'Forest Area' and prices of major forest products can be obtained by clicking on the topic *Prices* given under the topic 'Forest Products'. The source for each data set is indicated in the software appropriately for authenticity. The system also contains a glossary. The software is best viewed under the screen area 800 by 600 pixels.

This was an attempt to provide the database and retrieval system in an integrated manner after consulting a number of secondary sources. Therefore, there could be some errors and scope for improvement in presentation. The users of this package are welcome to send their valuable suggestions. As we intend to refine and update periodically, we would be able to incorporate the modifications suggested.

2.4 Installation of software and starting up for Windows users

Installation

1. Place the CD-ROM "A Database on Forest Resources of Kerala" in the CD-ROM drive of the computer.
2. Open the CD-ROM.
3. Double click on the setup.exe. On some computers the three letter extension (.exe) will not be shown automatically. In such cases the menu item is

represented by an icon depicting the computer with some diskettes and a small box in front of it.

4. Go on clicking on the appropriate buttons and at last click on the large button depicting the computer to start the installation.

How to start the program

1. Click on the start button in the menu bar.
2. Select Programs from the list now shown.
3. Select ‘Kerala Forest Resources’ from the subsequent list shown to start the program.

Deleting the program

1. Click on the Start button in the menu bar.
2. Select settings from the list now shown.
3. Select Control Panel from the list of Settings and click once on this item.
4. Select and open Add/Remove Programs in the Control Panel.
5. Select ‘Kerala Forest Resources ’ from the list of installed programs and click on the Add/Remove button.

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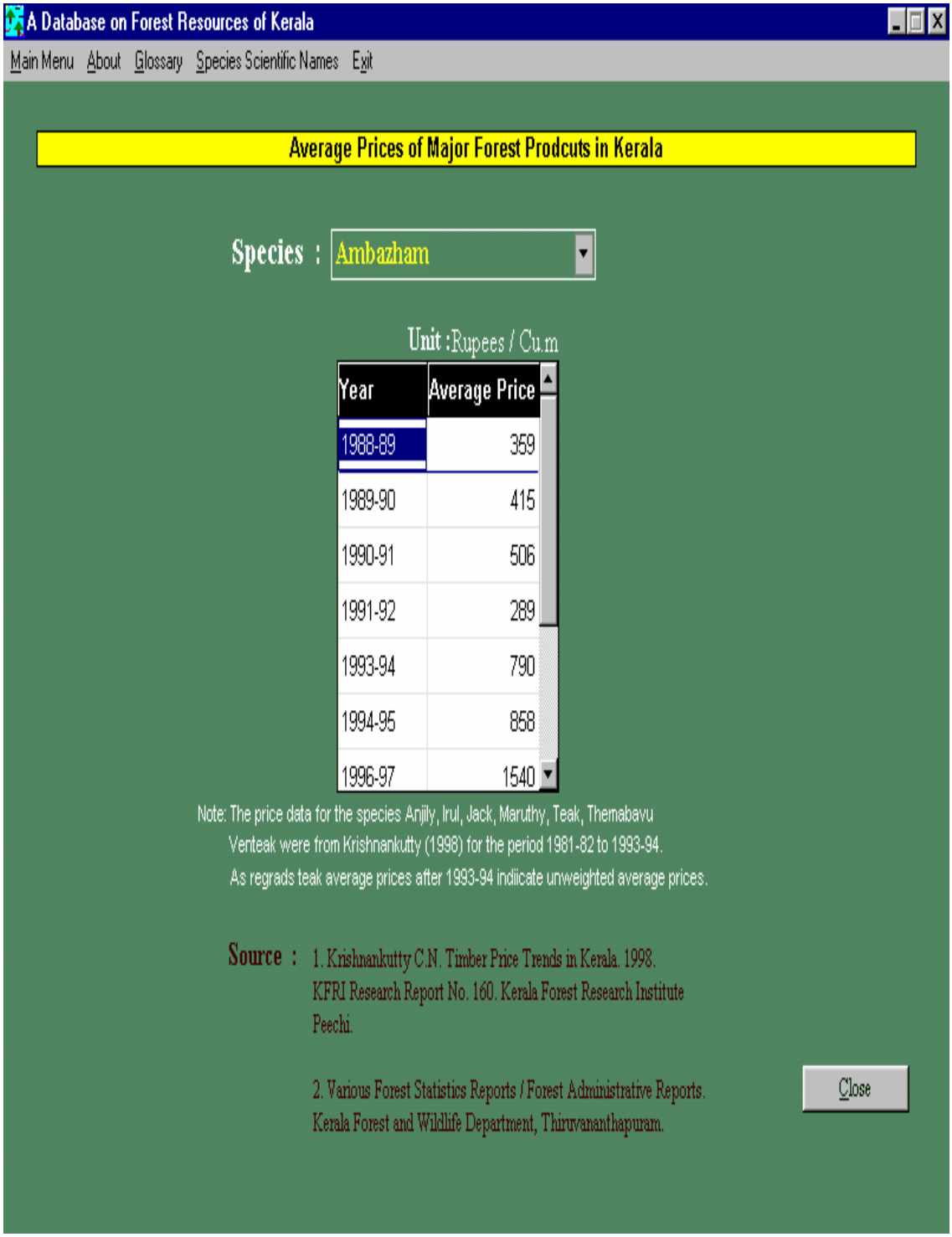
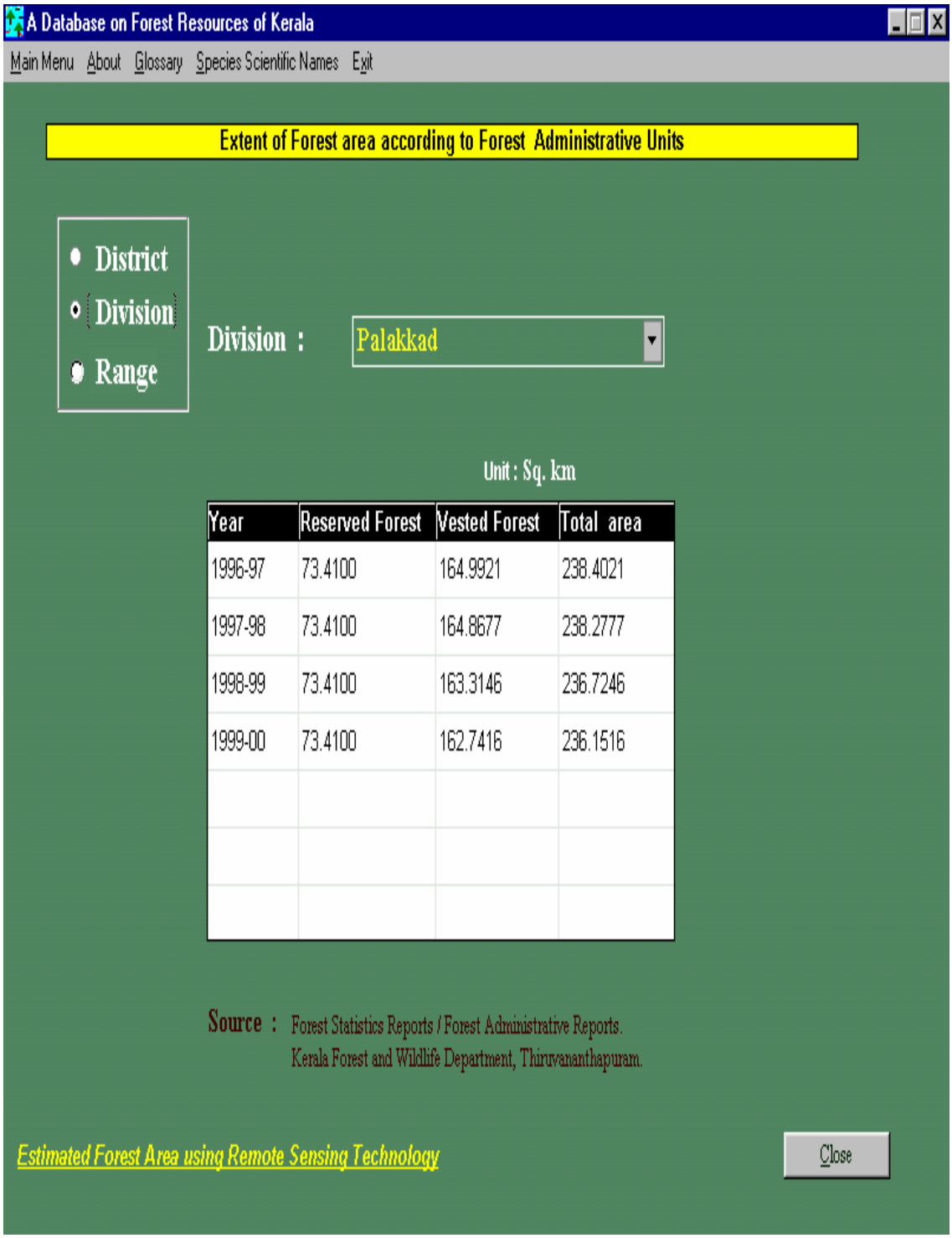
A Database on Forest Resources of Kerala
Main Menu About Glossary Species Scientific Names Exit
Forest Resources of Kerala
A Statistical Glance at Kerala and its Forests
Forest Administration
Administrative Units
Forest Check Posts
Forest Stations
Forest Timber Depots
Forest Area
Forest type, Land use, and Legal status
Spatial Distribution
Protected Forest Area
Deforestation
Forest Plantations
Spatial and Temporal Trend
Species - wise List
Productivity
Expenditure on New Plantations
Forest Products
Production
Prices
Biodiversity
Plant and Animal Biodiversity
Estimated Population of Major Mammals
Weather
Forest Fire
Revenue and Expenditure
Other Useful Data


A Database on Forest Resources of Kerala
Main Menu About Glossary Species Scientific Names Exit
Average Prices of Major Forest Prodcuts in Kerala
Species : Ambazham
Unit :Rupees / Cu.m
Year
Average Price
1988-89 359
1989-90 415
1990-91 506
1991-92 289
1993-94 790
1994-95 858
1996-97 1540
Note: The price data for the species Anjily, Irul, Jack, Maruthy, Teak, Themabavu
Venteak were from Krishnankutty (1998) for the period 1981-82 to 1993-94.
As regrads teak average prices after 1993-94 indiicate unweighted average prices.
Source : 1. Krishnankutty C.N. Timber Price Trends in Kerala. 1998.
KFRI Research Report No. 160. Kerala Forest Research Institute
Peechi.
2. Various Forest Statistics Reports / Forest Administrative Reports.
Kerala Forest and Wildlife Department, Thiruvananthapuram.
Close


A Database on Forest Resources of Kerala
Main Menu About Glossary Species Scientific Names Exit
Extent of Forest area according to Forest Administrative Units
District
Division
Range
Division :
Palakkad
Unit : Sq. km
Year
Reserved Forest
Vested Forest
Total area
1996-97
73.4100
164.9921
238.4021
1997-98
73.4100
164.8677
238.2777
1998-99
73.4100
163.3146
236.7246
1999-00
73.4100
162.7416
236.1516
Source : Forest Statistics Reports / Forest Administrative Reports.
Kerala Forest and Wildlife Department, Thiruvananthapuram.
Estimated Forest Area using Remote Sensing Technology
Close

3. Status of Forest Resources in Kerala

This part of the report attempts to appraise the status of forest resources in Kerala based on the data collected and presented in the database software during the study period. An analysis on socioeconomic causes of deforestation and projection of availability of teak wood up to the year 2050 have also been made. The gaps in the database developed and the issues and challenges related to developing comprehensive database are also discussed.

3.1 General features of the State

The State of Kerala is located at the southern extremity of the Indian subcontinent between 8^0 18' and 12^0 48' north latitudes and between 74^0 52' and 77^0 22' east longitudes. It is a State with great diversity of climate, altitude and edaphic factors. The total land area of the State is 38,863 km^2, which is 1.2 per cent of the total land area of India. The land of Kerala may be broadly divided into three geographical regions viz., lowland, midland and highland. The State has a coastline of nearly 550 km. There are 44 rivers in the State of which 3 are east flowing and the remaining west flowing. One of the striking features of the State is the continuous chain of lagoons or backwaters existing along the coastal region, and are all connected with one another by canals both natural and artificial. The Western Ghats, the chief mountain system, extend throughout the eastern boundary pierced by couple of gaps.

Geologically, the State can be divided into four distinct zones with more or less north south alignment. The classifications are (1) Crystalline rock, (2) Residual laterite, (3) Warkalli formation and (4) Recent formation. The soils of the State can be broadly classified into sandy, alluvial, laterite, red, black, peaty and forest hill soils. The sandy soils occur as a narrow belt all along the coast, and are extremely deficient in all the major plant foods. Lateritic soils are the most important group found in Kerala and cover the largest area.

There are two distinct rainfall seasons in Kerala viz., the Southwest (June to August middle) and Northeast monsoon, which last from September to November end. During these two seasons, about 90 per cent of the annual rainfall is precipitated in the State. The Southwest monsoon accounts for two third of this precipitation. The average rainfall is 3018 mm. Variation in temperature is from 23.9 to 37.7 ^{0}C in plains and from 10.0 to 32.2 ^{0}C in hills.

According to Census-2001, Kerala has a population of 3.2 crore which constitutes 3.4 per cent of the total population of the country. In terms of population density, Kerala has the highest density of 819 persons per km^2. Kerala State is the first one to achieve the highest literacy (91 per cent) and ranks first in the quality of life index. The State is divided into 14 administrative districts. The main occupation of the people is agriculture. The climate is conducive for the cultivation of a variety of crops (Nair, 1986; Anonymous, 1995a; Anonymous, 2000; Anonymous, 2001).

3.2 Forest and biodiversity

Forests benefit the people both directly and indirectly. Forests provide wood and non-wood forest products like pulpwood, medicinal plants, fibers, flosses, resins, honey, wax, etc. Forests influence the climate in a localized area by modifying the temperature and relative humidity. Forests regulate stream flow and control the surface runoff and thereby prevent soil erosion. Forests reduce wind erosion and harmful effects of strong winds, help in preventing floods and play a significant role in the removal of gas pollutants and particulate matter from the atmosphere, noise reduction, etc. Many kinds of wildlife are found in forests where they obtain shelter and food. The other better known values of forests include outdoor recreation, bird watching, nature study, trekking and scenic or aesthetic values (Anderson and Smith, 1976). The Kerala State is known for the presence of large extent of forest vegetation. The Western Ghats, its major portion is in Kerala, is one of the 24 global hotspots of biodiversity. According to the physical configuration of the State, the highland contains maximum forests while the midland has only little and coastal plains almost have no vegetation except for very few discontinuous patches of mangrove vegetation.

3.2.1 Temporal and spatial trend in the extent of forests

According to the Forest Survey of India, 1997, the total recorded forest area in India was 7,65,200 km^2. Out of this, forests in Kerala constituted 1.5 per cent (Anonymous, 1997). Though in the past, forests in Kerala covered more than one- third of the land area, at present the effective forest area is less than 20 per cent of the total land area whereas according to the National Forest Policy, the area under forests should be at least 33 per cent. The advent of Remote Sensing Technology and Geographic Information System has enabled to assess the extent of forests from time to time. In

the past, such an assessment of the extent of forests varied between different agencies. According to the National Remote Sensing Agency, the extent of forests in Kerala during 1972-75 was 8,611 km^2 and during 1980-82 it was 7,376 km^2. The reconciled figures brought about jointly by the National Remote Sensing Agency and the Forest Survey of India for the period 1981-83 was 10,402 km^2. An independent assessment made by the Forest Survey of India put the area as 10,149 km^2 for 1985-80 and 10,300 km^2 for 1993-95 (Jayaraman and Krishnankutty, 1990). The estimated extent of forest cover by Prasad (1998) was 10,820 km^2 in 1961 and 9,904 km^2 in 1988. According to the Forest Survey of India, in terms of forest canopy cover, the dense forest to the total forest area (forest with canopy density of 40 per cent or more) was 82 per cent and open forest (forest with canopy density of 10 to 40 per cent) was 18 per cent.

3.2.2 Extent of forests by legal status

According to the Kerala Forest Department the total forest area in Kerala was 11,124 km^2 (Anonymous, 2000). Of which, 82 per cent was declared as reserved forests and 16 per cent was declared as vested forests and 2 per cent of them was proposed to be brought under the reserved forests. The trends in the area under forests show that the area under reserved forests remained almost stable from 1980-81 to 1999-2000. The area under reserved land increased from 181 to 214 km^2 and the area under vested forests declined from 1,893 to 1,752 km^2 during the period (Table 1).

Table 1. Trends in the distribution of forest area according to legal status (km^2)

Year	Reserved forest	Reserved land	Total	Vested Forest
1980-81	9152.1580	181.8420	9335.9370	1893.1800
1981-82	9152.1580	181.8420	9335.9370	1890.4724
1982-83	9152.1580	181.8420	9335.9370	1887.1296
1983-84	9152.1317	181.8435	9334.9132	1886.5780
1984-85	9152.1317	181.8439	9323.9756	1886.5183
1985-86	9152.2260	182.3874	9336.5514	1881.6984
1986-87	9154.1640	184.3086	9338.4746	1884.7304
1987-88	9153.3279	184.4086	9326.7365	1887.5683
1988-89	9148.9305	185.4420	9334.3725	1892.4808
1989-90	9156.0057	185.4420	9341.4477	1888.5309
1990-91	9149.2780	185.4490	9334.7270	1888.5073
1991-92	9146.2754	185.4420	9331.7174	1888.2025
1992-93	9150.3917	183.0777	9333.4694	1887.1466
1993-94	9157.1587	183.0777	9340.2364	1896.7130
1994-95	9157.1587	184.7912	9341.9499	1890.8729
1995-96	9157.1587	184.7912	9341.9499	1893.1152
1996-97	9157.1587	213.9542	9371.1129	1755.3373
1997-98	9157.0037	214.3117	9371.3154	1754.0413
1998-99	9156.9838	214.3117	9371.2955	1754.1818
1999-00	9156.9838	214.3117	9371.2955	1752.9356

3.2.3 Extent of forests by vegetation type

According to the Kerala Forest Department the effective forest area in Kerala was 9400 km^2, which is 85 per cent of the total forest area (Anonymous, 2000). The distribution of detailed forest vegetation types in Kerala may be found in Chandrasekaran (1973b) and Nair (1991). According to

Fig. 1. Forest area according to vegetation type (km^2) -2000

the Kerala Forest Department, among the major forest types in Kerala, moist deciduous forests occupied 44 per cent, tropical wet evergreen and semi-evergreen occupied 35 per cent and plantations contributed to the extent of 19 per cent of the effective forest area. The extent of forest types of dry deciduous and montane sub-tropical temperate sholas and grasslands was negligible (Fig. 1). According to Prasad (1998), out of the total forest area of 9,904 km^2 in 1988, the deciduous forests constituted 41 per cent, evergreen/semi-evergreen forests 28 per cent, plantations 17 per cent and degraded and scrub land 14 per cent. The extent of forest under different administrative districts and forest divisions classified by vegetation class/ forest type are also available (Prasad, 1998; Prasad *et al.*, 1998; Jha *et al*., 2000). However, such figures could not be compared each other readily due to varying terminologies and definitions adopted.

3.2.4 Extent of forests by land use pattern

The forest area according to land use pattern shows that the majority of the forests were dense forests (67%). The plantations constituted 16 per cent of the total forest area. As much as 17 per cent of the total forest area was given to other agencies (Fig. 2).

3.2.5 Extent of protected forests

Under the protected forest management system, the Periyar Tiger Reserve was the first one formed in the year 1950 (Table 2). At present there are two National Parks and 12 Wildlife Sanctuaries covering 21 per cent of the total forest area. The proposal to form three more National Parks and 11 Wildlife Sanctuaries with the size of 550 km^2 and 1,552 km^2 respectively is under consideration (Rodgers et al., 2002). This means that another 19 per cent would be brought under the protected forests if the proposal is put to practice.

3.2.6 Extent of forests by administrative units

The recorded forest area according to different forest administrative units for 1999-2000 is presented in Table 3.

Table 2. Extent of Wildlife Sanctuaries and National Parks -2000

Wildlife Sanctuary / National Park	Area (km^2)	Year of formation
Neyyar	128.00	1958
Peppara	53.00	1983
Shenthuruni	100.32	1984
Periyar Tiger Reserve	777.54	1950
Chinnar	90.44	1984
Idukki	70.00	1976
Eravikulam National Park	97.00	1978
Thattekkad	25.00	1983
Chimmini	85.00	1984
Peechi-Vazhani	125.00	1958
Parambikulam	285.00	1973
Silent Valley National Park	89.52	1980
Wayanad	344.44	1973
Aralam	55.00	1981
Total	2,325.260	

Table 3. Extent of forests according to different forest administrative units – 2000

Circle	Division	Range	Area (km^2)
SOUTHERN			2,515.5484
	Thiruvananthapuram		369.8793
		Kulathupuzha	219.688
		Palode	107.5013
		Paruthippally	42.69
	Thenmala		205.6714
		Ariyankavu	73.9302
		Thenmala	131.7412
	Achankovil		269.0000
		Achankovil	84.0000
		Kallar	78.0000
		Kanayar	107.0000
	Ranni		1,059.1140
		Ranni	136.2867
		Goodrikkal	653.9673
		Vadasserikara	268.8600
	Punalur		280.2197
		Anchal	148.4116
		Pathanapuram	131.8081
	Konni		331.6640
		Konni	62.7280
		Naduvathumoozhi	138.9360
		Mannarappara	130.000
HIGH RANGE			1,724.9905
	Munnar		715.8411
		Munnar	106.0000
		Marayur	71.3173
		Devikulam	324.9114
		Adimali	110.8724
		Neriyamangalam	102.7400
	Kottayam		692.1520
		Erumeli	143.5620
		Ayyappankovil	106.9980
		Nagarampara	176.0000
		Kumili	265.5920
	Kothamangalam		316.9974
		Thodupuzha	218.3843
		Kothamangalam	12.1531
		Kaliyar	49.0800
		Mullaringad	37.3800
CENTRAL			1,522.0526
	Malayattoor		617.7659
		Kalady	72.5148
		Kodanadu	56.7411
		Thundathil	131.4000

		Kuttampuzha	357.1100
	Vazhachal		413.9438
		Charpa	59.9750
		Vazachal	90.6430
		Sholayar	138.8800
		Kollathirumed	29.3480
		Athirappally	95.0978
	Chalakudy		279.7098
		Pariyaram	115.3118
		Palappilly	55.9971
		Vellikulangara	108.4009
	Thrissur		210.6361
		Vadakkancherry	58.8560
		Pattikkad	59.4390
		Machad	92.3411
OLAVAKKODE			1,862.5580
	Nenmara		336.9357
		Nelliyampathi	205.9419
		Kollengode	49.6208
		Alathur	81.373
	Palakkad		236.7246
		Olavakkode	81.1784
		Valayar	121.8739
		Ottappalam	33.6723
	Mannarkkad		530.0293
		Attappadi	249.4309
		Agali	129.0923
		Mannarkkad	151.5061
	Nilambur North		393.7157
		Nilambur	140.6296
		Edavanna	97.8983
		Vazhikadavu	155.1878
	Nilambur South		365.1527
		Kalikavu	99.5451
		Karulai	265.6076
NORTHERN			1,127.4425
	Kozhikode		290.5519
		Peruvannamoozhi	127.5465
		Kuttiyadi	632812
		Thamarassery	99.7242
	Wayanad South		325.8895
		Kalpetta	123.0325
		Meppady	116.857
		Chethalayam	86.000
	Wayanad North		215.4839
		Begoor	104.7840

		Periya	84.6525
		Mananthavady	26.0474
	Kannur		295.5172
		Kannavam	93.8530
		Kottiyoor	63.1973
		Thalipparamba	27.5913
		Kanjangad	50.4117
		Kasargod	60.4639
AGASTHYAVANAM			312.4400
	Agasthyavanam Biological Park		31.1200
		Agasthyavanam Biological Park	31.1200
	Thiruvananthapuram		181.000
		Neyyar Wildlife Sanctuary	128.000
		Peppara Wildlife Sanctuary	53.000
	Shenthuruni		100.3200
		Shenthuruni sanctuary	100.3200
FIELD DIRECTOR, PROJECT TIGER			1,095.5098
	Idukki		130.5240
		Idukki	105.3640
		Thattekkad	25.1600
	Thekkady		777.5438
		Thekkady	422.5438
		Vallakkadavu	355.0000
	Eravikulam		187.4420
		Eravikulam National Park	97.0000
		Chinnar Wildlife Sanctuary	90.4420
WILDLIFE			763.2075
	Parambikulam		274.1408
		Sunkom	81.7508
		Parambikulam	52.1800
		Orukomban	71.8370
		Karimala	68.3730
	Silent Valley		89.5165
		Silent Valley National Park	89.5165
	Wayanad		344.5502
		Tholpetty	77.669
		Kurichiyatt	106.5602
		Muthanga	74.2927
		Bathery	86.0283
	Aralam		55.0000
		Aralam	55.0000

3.2.7 Forest biodiversity

Plant diversity

Forests contain rich diverse biological organisms. The Western Ghats, its major portion is in Kerala, is one of the 24 global hotspots of biodiversity. Among the three categories of biodiversity, genetic, species and habitat it is the species diversity, which is the most studied and genetic diversity is the least explored. The ecosystem diversity is partially understood, i.e., restricted to the recognition of major forest types. The plant species in Kerala have been recorded since the middle of 17^{th} century. An account of plant diversity of forests in Kerala is given by Nayar (1997). Apart from the number of species reported in Table 5, there are 200 species reported to be added to the total figure. Sasidharan (2002) has given a detailed account of diversity and distribution of flowering plants of Kerala. The status including number of endemic plants are given in Table 6. Out of 4,527 flowering plants, 20 per cent belonged to tree species, 30 per cent shrub species, 41 per cent herb species and 9 per cent climbers. A Handbook prepared by Sasidharan (2000) provides a complete index of the trees in Kerala. Information on 740 indigenous and 110 exotic tree species are available in the checklist.

Table 5. Number of species reported under each plant group

Plant group	Number of species
Angiosperms	3,800
Gymnosperms	4
Pteridophytes	236
Bryophytes	350
Lichens	520
Algae	325
Fungi	4,800
Total	10,035

Table 6.Status on flowering plants of Kerala

Total	Family	Genera	Endemic (PI*)	RET**	Trees	Shrubs	Herbs	Climbers
4,527	197	1,334	1,381	496	925	1,355	1,868	379

*Peninsular India ** RET-Rare, Endangered and Threatened

Animal diversity

Nair and Easa (1997) have given a detailed account of animal diversity in Kerala (Table 7). They have emphasized the need for updating, as the list is very incomplete.

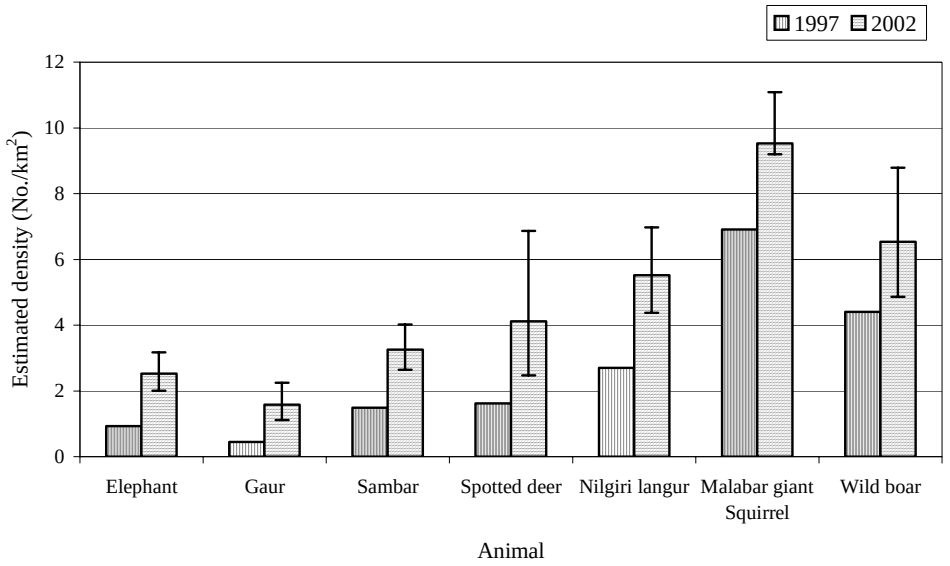
Table 7. Minimum number of genera/species of animals recorded

Groups	No. of Genera	No. of Species
Vertebrates (animals with backbone)		
Pisces (fishes)		196
Amphibia (amphibians)		86
Reptilia (reptiles)		142
Aves (birds)		475
Mammalia (mammals)		75
Invertebrates (animals without backbone)		
Protozoa	63	
Porifera (sponges)	22	
Coelenterata (jelly, fish, corals)	90	
Platyhelminthes (Flatworms)	117	
Acanthocephala	16	
Aschelminthes	265	
Annelida (earth worms, leaches)	46	
Chaetognatha	4	
Mollusca (snails, oysters)	19	
Echinodermata (starfish, sea cucumbers)	7	
Insecta (insects)	193	
Non-insect Anthropoda (crustaceans, mites, spiders)	242	

Population of major mammals

Wildlife management requires information on the abundance and distribution of wildlife population in various parts of the forest. In this regard, in 1993, the State Government, based on the recommendations of the State Wildlife Advisory Board, took the policy decision to conduct the wildlife population estimation with the public participation. To this effect, the Kerala Forest and Wildlife Department in collaboration with the Kerala Forest Research Institute has conducted three wildlife

censuses during the years 1993, 1997 and 2002 and the figures on the population of major animal species are available (Anonymous, 1993a; Easa and Jayaraman, 1998; Easa, Sivaram and Jayson, 2002). The reports can be referred for more details on the methodology adopted. However, a brief description is provided here. The census was conducted for four days following different survey techniques with the participation of the public. The total forest area was divided into a number of small blocks utilizing the maps of the Survey of India. The blocks served as the basic units for the survey. The survey techniques adopted were 1) Block count (direct sighting), 2) Line transect sampling (direct sighting), 3) Line transect sampling (dung survey) in the case of elephant and gaur and 4) Plot level survey of indirect evidences in the case of sambar deer, spotted deer, barking deer, mouse deer, wild boar, porcupine, small Indian civet, common palm civet, sloth bear and wild dog. The division-wise and region-wise density figures of animal and indirect evidences are available in the reports. The estimated State level density for the selected animal species are presented in Figure 3. It reveals that there was an increasing tendency in the density of the animal species considered. The estimated number of animals is not presented here on technical considerations.



I – indicate the 95 per cent lower and upper limits of the density estimate during 2002

Fig. 3. State level density estimates of selected wildlife species in the forests through line transect sampling technique

3.2.8 Forest resources assessment

The forest is a dynamic organism subject to growth, decay and death. It is not enough, therefore, merely to know what exists in the forest at any one time. It is necessary to make re-inventories at regular intervals and know the spatial distribution of various species, number of tress under each species, the rate of growth, mortality etc. In the past, the state level quantitative assessment of forest resources was concentrated on wood resources. Chandrasekaran (1973a) was the first one to assess the forest resources (confined mostly to wood) in quantitative terms. The growing stock in the forests of Kerala was 18.5 crore m^3 of wood, 46 lakh tons of airdry reeds and 18 lakh tons of airdry bamboo. The growing stock in the government forests of Kerala (excluding vested forests) was estimated to be 15.5 crore m^3 of wood, 46 lakh m^3 of airdry reeds and 14 lakh m^3 of airdry bamboo.

According to the Forest Survey of India 1995, the growing stock of Kerala Forests was 9.89 crore m^3 and volume per ha was 95.67 m^3. The estimated annual increment was 19.83 lakh m^3 (Anonymous, 1995b). The important species in each major forest type are given in Table 8.

Table 8. Important species in different major forest types

Forest types	Important Species
Tropical wet evergreen and semi evergreen forests	*Artocarpus hirsuta, Calophyllum tomentosum, Canarium strictum, Cinnamomum zeylanicum, Cullenia excelsa, Dipterocarpus spp. Dysoxylum malabaricum, Michelia champaca, Mesua ferrea, Terminalia paniculata* etc.
Tropical moist deciduous forests	*Adina cordifolia, Bombax ceiba, Dalbergia latifolia, Ficus glomerata, Kydia calicyna, Lagerstroemia lanceolata, Pterocarpus marsupium. Tectona grandis, Terminalia spp.* etc.
Tropical dry deciduous forests	*Acacia spp. Azadirachta indica, Butea frondosa, Cassia fistula, Dalbergia paniculata, Sterculia urens* etc.
Montane subtropical and montane temperate forests	*Bischofia javanica, Calophyllum tomentosum, Cedrela toona, Eugenia spp, Ficus glomerata, Machilus micrantha, Mallotus spp., Rhododendron,* spp., *Lauraceous trees.*

Jayaraman and Chacko (1997) assessed the growing stock in teak and eucalyptus plantations of Kerala. The estimated growing stock of teak plantations of age greater than 10 years belonging to territorial forest divisions of Kerala was 23.5 lakh m^3 of timber and 15.9 lakh m^3 of small timber. The total growing stock of commercial volume of eucalypts in the state was 10.4 lakh m^3.

Forests also contain variety of Non-Wood Forest Products (NWFPs), which include a wide variety of products from day to day use, household articles, fodder, etc. to raw materials to industries. Though NWFPs play a crucial role in the employment and income generation to tribal and rural communities and meets a variety of their needs, in the past the forest management policies were aimed at generating more income from timber and firewood and the NWFPs received little attention. However, during the last few decades there has been an increase in the demand for NWFPs and subsequently many NWFPs have been over-exploited disproportionate to their regeneration capacity. It is reported that there are 550 species of plants yielding NWFPs in Kerala (Nambiar *et al*., 1985). Medicinal properties are reported for about 500 species of forest plants in Kerala. Out of this about 150 are used in the preparation of medicine on a commercial basis and others are used in the traditional system of medicines and tribal medicine (Muraleedharan *et al*., 1999). Among the NWFPs, herbs, shrubs and small climbers comprise 322 species, which grow among the lower most stratum of forests.

The present day forest plantations were once the habitats of valuable NWFPs, still have several NWFP species growing as undergrowth. A recently conducted study (Sasidharan and Sivaram, 2003) indicated that NWFP resources in teak plantations in terms of abundance, diversity, availability of useful parts and annual economic return were comparable with moist deciduous forests and other plantations. This indicated that teak plantations should also be valued for NWFP resources apart from timber. The state-wide inventory of NWFP resources has not been carried out so far. Currently, efforts are underway to make an inventory of nearly 135 NWFP species all over Kerala by the Kerala Forest Research Institute (KFRI) and Tropical Botanical Garden and Research Institute (TBGRI).

3.3 Socioeconomic causes of deforestation

Degradation and loss of forests have impacts on the ecosystem functions, biodiversity and natural resources. While the extent of forest in developed countries has stabilized, deforestation continues in developing countries. Jha *et al* (2000) stated the annual deforestation rate in India to be 0.4 per cent to 0.6 per cent for the period 1981 to 1990. Increase in forest area in India was reported as 0.1 per cent per annum for the period 1990 to 2000 (FAO, 2001). At the regional level, the estimated annual deforestation in Western Ghats was 0.57 per cent and 1.16 per cent during the periods 1920 to 1990 and 1973 to 1995 respectively (Menon and Bawa 1997; Jha *et al*., 2000). Prasad (1998) assessed the annual deforestation rate in Kerala to be 0.28 per cent for the period 1961 to 1988.

Our understanding of the social and economic factors leading to deforestation are mostly based on international comparisons and they attribute deforestation to population pressure, competition for land, exploitation of forest products, cattle density, natural disasters and per capita external debt (FAO, 2001; Bawa and Dayanandan, 1997). Such cross-country analyses mask considerably, the variation within and among countries (Menon and Bawa, 1997). Therefore, there has been emphasis to identify the causes at a smaller scale to design more effective mitigation strategies and conservation measures (Menon and Bawa, 1997; Bawa and Dayanandan, 1997; Jha *et al*., 2000). In this context, an attempt has been made here to understand the causes of deforestation in the State of Kerala.

3.3.1 Methodology

Recently, Prasad (1998) has reported the district level loss of forest cover in Kerala for the period 1961 to 1988 based on published images. The availability of this data and the district level data on selected socio-economic factors from various sources (Anonymous 1988, 1993b and 1995; Krishnankutty, 1990) prompted and made possible to explore the causes of deforestation in Kerala. The socio-economic factors considered in this study are population density, literacy rate (per cent literate to population aged 7 years and above), per capita income, livestock density, land use pattern and per capita demand and production of wood.

The extent of loss of forest area reported by Prasad (1998) depends on the accuracy of the maps and the methods used which the author has discussed in detail. Further, in

the present study, the rate of deforestation was based on a period of nearly 30 years (1961 to 1988), whereas the data on socio-economic factors of various districts relate to the years 1987-1988 and 1991. The data on socio-economic conditions pertaining to later years might by and large, reflect the differential pattern prevailed in the past. In fact, the difference between the districts might have been much wider in the past.

The relationships between deforestation and socio-economic factors were examined using Pearson's correlation coefficient and Spearman's rank correlation coefficient. The former is based on original scale and the later based on ranked or ordinal scale. Multiple regression technique was applied to understand the relative importance of different variables. In this study, the per cent change in the deforestation rate was related with absolute figures of the socio-economic variables pertaining to one year. The change analysis (analysis of relating change in the variable of interest to the change in its correlates that took place during the defined time period), as being carried out in the studies of population demographic would have been ideal in the present context (Haines *et al.*, 1983, DaVanzo and Habicht, 1986). But the non-availability of appropriate historical data, variations in the definitions of the variables and bifurcation of districts from time to time limited such an attempt. In the analysis, out of 14 districts of Kerala, Alappuzha and Kasargod were excluded because Alappuzha had no forest area according to Prasad (1998) and Kasargod was found to be an outlier of the data set.

3.3.2 Results and discussion

The district level annual rate of deforestation in Kerala ranged from -0.96 per cent in Palakkad to 2.10 per cent in Kozhikode for 30 years period. The results of correlation analysis indicate the increase in deforestation in districts having higher level of literacy (both rural and urban), cattle density, goat/sheep density, total livestock density and per capita demand for wood at varying levels of significance. On the other hand, the decline in deforestation was found to be significantly related with the increase in the buffalo density, proportion of forest area to total forest area, proportion of forest area to total land area and proportion of wastelands to total land area (Table 9). The selected significant variables from each category viz., total literacy rate, cattle density, proportion of forest area to total land area, proportion of wastelands to total land area and per capita demand for wood were alone included in the multiple regression analysis. In all the three procedures of regression analysis (forward,

backward and stepwise), literacy rate alone emerged significant explaining 50 per cent of variance in annual deforestation rate (β=0.74, P<0.01). Other appropriate combinations of significant variables were also tried in the regression model but the literacy rate alone emerged significant. In other words, the adjusted effect of literacy rate was predominant.

In general, the relative importance of the variables also depends on the number of relevant variables included in the regression model. However, within the scope of the variables studied, it may be concluded that the differential literacy rate of the districts served as an underlying indicator variable of the deforestation that occurred during 1961-1988. This is a new finding in the studies of deforestation, unlike in the field of demography, where the literacy rate is often linked to a number of developmental indictors such as mortality rate, fertility rate and so forth (Mosley, 1984). It is also interesting to note that, although Kerala State has high literacy rate ranging from 81 per cent in Palakkad to 96 per cent in Kottayam as on 1991, such differences between districts explained variation in deforestation rate considerably. The pathways and the mechanism behind the relationship of increase in deforestation in districts having higher level of literacy are difficult to explain. One explanation could be that the higher literacy rate was population centric and strongly linked to developmental processes and thus leading to pressure on neighboring forests for want of infrastructure (e.g. housing) and wood requirements. Path analysis might have empirically brought out the causal mechanism but could not be applied due to limitations of the data. Nonetheless, the present attempt has brought out a few factors related to deforestation, which have policy and management implications. It may be pointed out that the forest conservation policies are formulated and implemented in totality at the state level. This study indicates that such polices should also take into account the district level socio-economic conditions. It may be mentioned that although the present study has shown the pattern of relationship between differential literacy and annual deforestation, in-depth studies in specific geographic regions are required to examine the temporal relationship between gain in literacy and rate of deforestation. There have been too fee studies on the rate of

Table 9. Correlation between deforestation and selected socio-economic factors

Socio-economic factors	Range	**Pearson's Correlation coefficient**	**Spearman's Correlation coefficient**
Population density (No. /km^2)[1]			
Rural	200 - 891	0.27	0.30
Urban	10 - 584	0.45	0.35
Total	209 - 1347	0.41	0.38
Literacy rate (in percentage) [1 $]			
Rural	80.2 - 95.7	0.73***	0.76***
Urban	84.2 - 95.9	0.70**	0.59**
Total	81.3 - 95.8	0.73***	0.69**
Per capita income (in Rs.)[1]	869 - 2142	0.44	0.48
Livestock density (No. /km^2) [2]			
Cattle	37 - 138	0.56**	0.63**
Buffalo	2 - 17	-0.66**	-0.67**
Goat/Sheep	15 - 124	0.24	0.50*
Total	56 – 262	0.40	0.49*
Land use pattern[2] (in percentage to total land area) [$]			
Forest area-I@	(1.0-27.5)	-0.36	-0.56*
Forest area-II@	(3.4-52.2)	-0.52*	-0.39
Non agricultural land	(3.3-14.7)	0.37	0.48
Barren land	(0.2-2.5)	-0.32	-0.22
Pasture land	(0.0-0.1)	-0.05	-0.24
Land under tree crops	(0.0-2.2)	-0.28	-0.31
Waste land	(0.2-5.0)	-0.56*	-0.58*
Fallow land	(0.4-3.3)	-0.44	-0.45
Per capita demand and production[2-4]			
Per capita demand for wood (m^3)	+	0.56*	0.59**
Per capita production of wood (m^3)	+	-0.32	-0.41
Growing stock volume in homesteads to total land area[$] (000'm^3)	(0.02-0.05)	-0.02	-0.22
Growing stock volume in homesteads to total forest area[$](000' m^3)	(0.02-0.06)	0.43	0.31

*** - P<0.01 ** - P<0.05 * - P<0.10

Superscripts 1-4 indicate the sources of data for analysis: 1. Anonymous (1993b), 2. Anonymous (1995), 3. Anonymous (1988), 4. Krishnankutty (1990)

@ Forest area-I refers to proportion of forest area to total forest area of the state
Forest area-II refers to proportion of forest area to total land area of the state

+ -works out to be very small values. For the purpose of computing correlation coefficient easily, the values were multiplied by a larger constant.

Log transformation was taken on annual deforestation rate and on the variables indicated by $ sign.

Population and literacy rates pertain to the year 1991. Per capita income, livestock density, land use pattern, demand and production of wood relate to the year 1987-1988.

deforestation, causes of deforestation and the history of encroachment of forest lands, etc. Nair (1991).

3.3.3 Limitations

Apart from the recognition of the data limitations indicated earlier, it is also acknowledged that the relationship obtained at macro level data (using district, state or country level data) need not always be taken as cause-effect relationship but only exhibit the trend present. However, such studies are routinely carried out on low cost consideration. On the other hand, micro level studies are costly and bring out information only specific to study areas. In this study, the differences in literacy rate explained the differences in deforestation rate between the districts. Such district level trend might not be true at the micro level. The analysis attempted was purely exploratory.

3.4 Forest Plantations and Productivity

3.4.1 History of forest plantations

Teak and eucalypt are the major forest plantation species in Kerala. The history of teak plantations in Kerala has been discussed by Chundamannil (1993). The beginning for the establishment of teak plantations was first made at Nilambur, which dates back to 1842. It later grew to become the genesis of network of teak plantations in India. With the introduction of working plans from 1895 to 1905 and 1906 to 1915, teak plantations were brought under systematic management for the scientific working. The period after the Second World War was marked by a sincere effort in afforestation in areas ravaged by excessive felling during the war period. Teak was the most preferred species for raising plantations during this period. During the early 1960's liberal approach was considered advisable in selecting areas for raising teak plantations due to preference over even poor quality teak. Consequent to this teak plantations were raised extensively. Further, the initiation of planned development under Five Year Plans accelerated the plantation activity in Kerala. Plan funds were provided for the establishment of plantations. Even special teak plantation divisions were formed for intensive expansion and management of teak plantations. In the year 1922, 'taungya' system of raising teak plantation was introduced. However, it was discontinued in the early 1980's in view of its adverse effects on the soil and plant growth (Rao *et al*., 1997). Mixed planting of teak with softwood species from 1970 onwards and bamboo as under planting in 1980's were other important management strategies adopted. The great majority of teak plantations in Kerala have been established under the government plantation programmes. However, teak has also attracted the interest of the private sectors in the recent past. In Kerala, home-gardens are also an important source of teak. Eucalypt, an exotic species, first raised in late 1950s, has now expanded greatly. These plantations mostly comprise *Eucalypt grandis* in high elevation and *Eucalypt tereticornis* in low elevation.

3.4.2 Temporal trends in the extent of forest plantations

During the year 1999-2000, the total area under forest plantations was 16 per cent of the total forest area of 11,124 km^2. Teak and eucalypt have been the principal forest plantation species in Kerala. The changes in the area under plantations reveal that the total area under plantations of all the species was exponentially increasing. The total area under plantations increased from 1,43,221 ha during 1980-81 to 1,79,169 ha

during 1999-2000 by 25 per cent with an annual increase of 1.3 per cent. The area under teak plantations was exponentially increasing till 1980 and thereafter remained constant indicating no expansion.

The area under eucalypt plantations came into existence in 1960 and since then there was a steep increase until 1980. During 1980-1990, there was not much change but during 1990-2000 there was a declining trend in the area under eucalypt (Fig. 4 and 5).

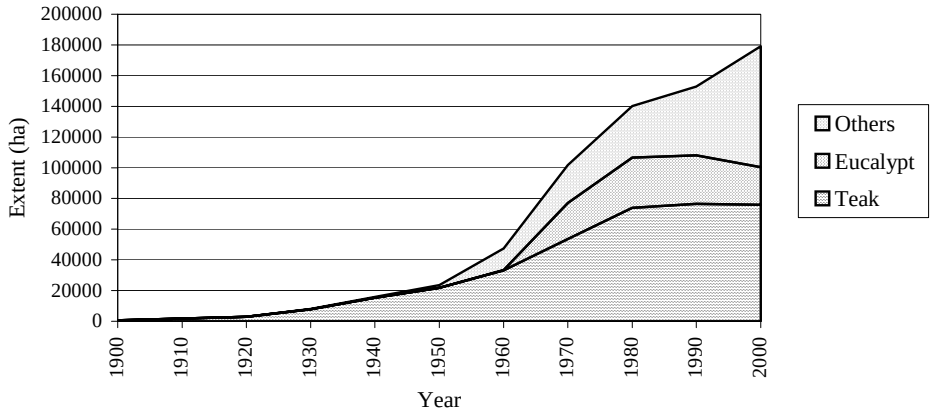


Fig. 4. Decadal trend in the extent of teak and eucalypt plantations (1900 to 2000)

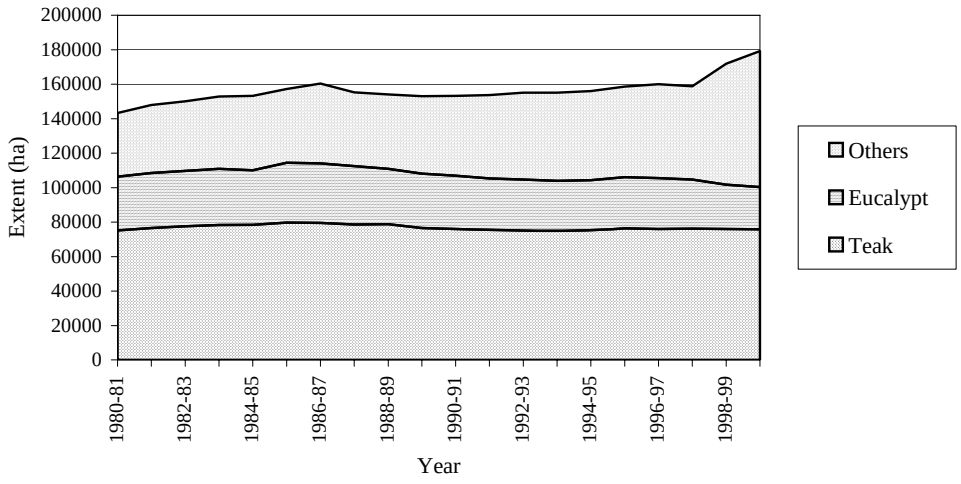


Fig. 5. Annual trend in the extent of teak and eucalypt plantations (1980-2000)

3.4.3 Present status of the extent of forest plantations

The great majority of teak plantations have been under the purview of government agencies mainly the Kerala Forest Department. There was no information on the extent of forest plantations with the private parties. During the year 1999-2000, the total area under plantations in Kerala was 1,82,000 ha. Out of this, as much as 1,79,147 ha belonged to the Kerala Forest Department (KFD) and 10,717 ha belonged to the Kerala Forest Development Corporation (KFDC).

Fig. 6. Extent of forest plantations by type of species under KFD -2000

As much as 43 per cent of the total area of plantations under KFD belonged to hardwood species, 21 per cent belonged to softwood species and 33 per cent was of mixed species. The area under plantations of bamboo and reeds was only to the extent of 2 per cent (Fig. 6).

The species-wise distribution of area under plantations that come under the purview of the Kerala Forest Department are given in Table 10. Of the total area under plantations in Kerala, teak being the major hard wood species,

Fig. 7. Extent of teak and eucalypt plantations under KFD -2000

Table 10. Species-wise area under forest plantations- 2000

Name of the species	Area (ha)
Hardwood	
Teak	75,883
Rosewood	414
Mahogany	81
Sandalwood	73
Bamboo and Reeds	
Cane	995
Reeds	525
Bamboo	2,658
Plantation Crops	
Coffee	508
Pepper	310
Zynamon	4
Medicinal Plants	557
Softwood	
Eucalypt	24,458
Grevellia robusta	709
Pine	549
Albizia	221
Rubber	88
Balsa	93
Wattle	3,387
Murukku	49
Matti	501
Mixed Plantation	
Cashew	6,246
Fuel wood	218
Agave	47
Alnus	137
Acacia	2,368
Sesbania	21
Casuarina	69
Kongograss	140
Malbury	2
Palm trees	14

contributed as much as 42 per cent and eucalypt, a major softwood species, contributed 14 per cent (Fig. 7).

As indicated earlier, apart from the Kerala Forest Department, the Kerala Forest Development Corporation (KFDC) has also been undertaking planting, maintenance and promotion of forest plantations. It had 10,717 ha of plantations under its jurisdiction. Majority of the plantations were pulpwood species to the extent of 56 per cent. The teak and soft wood constituted only 11 per cent (Fig. 8).

Fig.8. Extent of forest plantations by type of species under KFDC - 2000

3.4.4 Spatial distribution of forest plantations

Out of the total area of 1,79,147 ha under plantations, 81 per cent belonged to territorial divisions and the remaining 19 per cent belonged to wildlife divisions. The plantations that come under the wildlife divisions do not come under the regular management practices such as felling, thinning etc. The division-wise area under plantation in territorial circles for various species is presented in Table 11. In terms of the total extent of plantations, Munnar ranked first followed by Konni, Malayattoor, Nilambur (North) and Achenkovil having more than 9,000 ha. The lowest total area under plantations was in Perumbavoor followed by Mankulam. Among the wildlife divisions, as high as 11,097 ha of forest plantations were found in Wayanad Wildlife Division followed by Parambikulam Wildlife Division (8872 ha). In both these divisions, teak was the major species (Table 12).

Out of the total area under teak plantations, territorial divisions occupied 78 per cent and the remaining 22 per cent was under the purview of the protected area management. As regards the extent of teak plantations, Konni division ranked first followed by Malayattoor, Nilambur (South), Chalakkudy and Nilambur (North) in that order respectively.

Out of the total area of 24,461 ha of eucalypt plantations, 68 per cent was in territorial divisions and the remaining 32 per cent was in wildlife divisions. Among the territorial divisions, the major ones, which had eucalypt, were Nilambur (North), Munnar, Thiruvananthapuram, Punalur and Wayanad (South). Among the wildlife divisions, Peerumadu had the highest area under eucalypt (6847 ha).

3.4.5 Age structure of teak plantations

The age structure of presently available plantations determines the future outturn of timber. The list of plantations as on year 2000 obtained from all the forest divisions was classified according to age groups and presented in Figures 9 and 10 for territorial and wildlife divisions respectively. The teak plantations that come under the territorial divisions covered all the age groups ranging from 0-4 years to 59 years and above and nearly 60 per cent of them were found in the age group of 20-40 years. As far as teak plantations in the wildlife divisions were concerned, they were mostly found in the age group of above 15 years.

3.4.6 Age structure of eucalypt plantations

Although eucalypt species are worked under a rotation of 8 years, the age structure of the existing plantations that come under KFD show that more than 80 per cent of the total area under plantations crossed 8 years and 56 per cent was found in the age group of 25 years and above (Fig.11).

Table 11. Extent of forest plantations (ha) in different territorial divisions- 2000

Name of Division	Hardwood		Softwood		Mixed	Cane, Reeds & Bamboo	Plantation crops	Total
	Teak	Total	Eucalypt	Total				
Thiruvananthapuram	585	1048	2692	2774	2644	18	–	6483
Thenmala	1544	1574	589	2304	382	142	30	4431
Punalur	1339	1416	1436	1512	3059	88	22	6096
Achenkovil	2203	2434	-	2113	4082	159	104	8892
Ranni	3285	3336	-	40	2733	480	10	6598
Konni	7940	8091	28	57	826	677	10	9660
Kottayam	2954	3098	159	292	3377	75	22	6864
Munnar	726	726	2894	6998	3408	155	10	11297
Kothamangalam	4811	4859	141	369	790	84	20	6120
Mankulam	-	-	100	180	141	121	-	442
Malayattoor	5590	5620	436	520	2987	144	78	9349
Vazhachal	3932	3932	212	528	2604	156	73	7292
Chalakkudy	4578	4578	-	108	1246	39	10	5981
Thrissur	2119	2138	655	655	5328	140	-	8261
Perumbavoor	36	36	-	-	26	-	-	62
Nenmara	1140	1140	100	330	1404	128	4	3005
Palakkad	928	928	-	-	1875	-	-	2803
Mannarkkad	1985	2062	393	395	2616	69	72	5213
Nilambur (South)	4788	4815	210	210	527	5	10	5557
Nilambur (North)	4047	4047	3449	3598	1368	64	-	9087
Kozhikode	308	308	687	1379	382	86	58	2213
Wayanad (South)	2476	2478	1706	2093	1297	197	488	6553
Wayanad (North)	518	518	746	858	1783	213	64	3436
Kannur	1035	1238	-	20	8316	557	142	10273

Table 12. Extent of forest plantations (ha) in different wildlife divisions -2000

Name of Division	Hardwood		Softwood		Mixed	Bamboo	Plantation crops	Total
	Teak	Total	Eucalypt	Total				
Agasthyavanam	42	42	158	200	627	70	11	950
Thiruvananthapuram	10	10	-	-	915	54	6	984
Shenthuruni	-	-	-	-	209	114	-	324
Idukki	293	305	-	-	1329	54	-	1688
Eravikulam	-	-	-	-	-	-	-	35
Peerumedu	-	-	6847	6847	-	-	-	6847
Thekkady	-	-	173	173	75	-	-	248
Peechi	385	385	-	157	892	91	100	1625
Parambikulam	8569	8569	53	53	216	-	35	8872
Silent Valley	-	-	-	-	-	-	-	-
Wayanad	7427	7487	430	2548	1062	-	-	11097
Aralam	292	292	167	167	50	-	-	509

Fig. 9. Age structure of teak plantations under territorial divisions- 2000

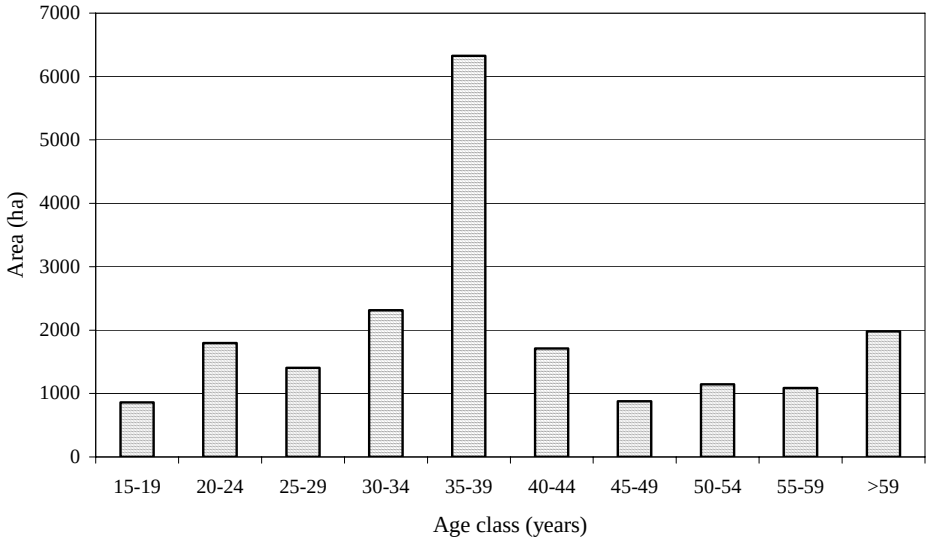


Fig.10. Age structure of teak plantations under wildlife divisions- 2000

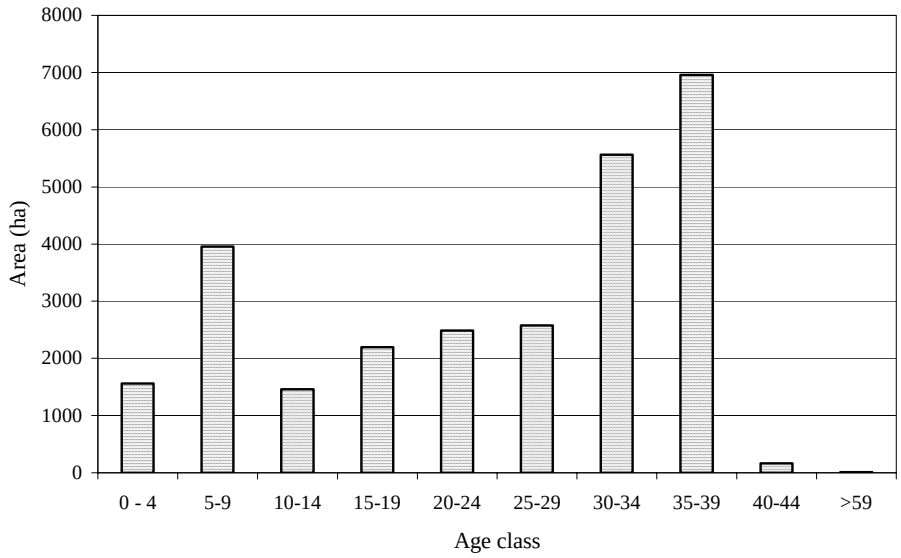


Fig. 11. Age structure of eucalypt plantations- 2000

3.4.7 Productivity and volume estimates of teak

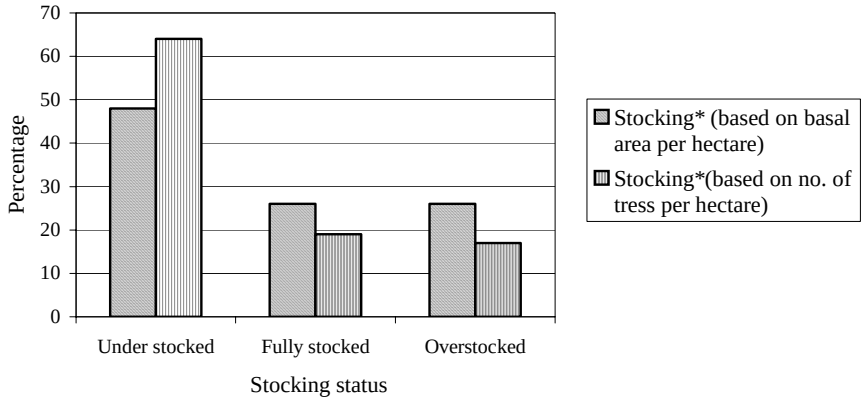
Productivity

Relative humidity and annual rainfall were identified as the most important factors influencing the growth of teak (Pandey, 1996). There is high degree of regional variation in the productivity of teak plantations in Kerala due to variability in soil, topography and weather conditions in the State (Jayaraman and Rugmini, 1993). Productivity figures from existing plantations covering a wide range of environmental conditions and management regimes are limited.

Stocking and site quality

The productivity of teak depends on the stocking and site quality of the plantations apart from the quality of planting materials, the extent of pest and disease problems. An assessment made by Jayaraman and Chacko (1997) showed that the most of the teak plantations in Kerala belonged to moderate site quality classes either II or III (Fig. 12). In terms of stocking based on either basal area or number of trees, most of the plantations are either under stocked or overstocked (Fig. 13).

Fig.12. Percentage of plantations belonging to different site quality classes



- Plantations having stocking ratio between 0.9 and 1.1 were taken as fully stocked

Fig. 13. Percentage of plantations with different stocking status

Thinning and rotation age

Thinning is an important operation to reduce competition between trees for producing commercially sizeable timber. The prescribed thinning years are 4, 8, 12, 18, 28 and 40 years. However, in practice, there is a variation in thinning years followed. The average thinning years worked out by Jayaraman and Chacko (1997) based on the data obtained from the records of the forest department are 7, 10, 16, 24, 31 and 35 years.

Rotation age is the time between establishment of plantations and clear felling of the final crop. It is mostly determined by the economic return. In the field, it varies across geographic boundaries due to factors such as latitude, aspect, altitude, climatic conditions, site-specific factors etc. An important feature of teak yield tables is early peak of mean annual increment, generally between six and 20 years. Because teak is

planted and managed for timber production with good size, the determination of harvesting age is important rather than the age of maximum volume production. The rotation age of plantation teak in its natural range has varied between 50 and 90 years, while outside the natural range the rotation age is between 40 and 60 years (Pandey and Brown, 2000). In general, teak plantations in Kerala are managed on a rotation age of 50 to 60 years.

Volume estimates

There is a paucity of data on actual yield at harvest of teak from different site quality classes. The general conclusion arrived from the available data is that the actual productivity has often been much lower than indicated in the yield tables.

Expected yield in India is 4 to 6 m^3 ha^{-1} yr^{-1} over the likely rotation length (Leech, 1998). MAIs obtained from government owned plantations range from 2 to 5 m^3 and are often below the potential yield of the site (Enters, 2000). The actual yield obtained from thinnings and final fellings in Konni forest was reported to be 2.5 at 70 years (Pandey and Brown, 2000). Estimates of MAI of teak at 60 years including yield from thinning for different forest divisions were worked out by Jayaraman and Chacko (1997) based on the data collected from standing crop. The MAI varied from 4.007 m^3 ha^{-1} in Kozhikode division to 2.161 m^3 ha^{-1} in Kothamangalam at 60 years. The State level MAI was 3.110 m^3 ha^{-1}. Chundamannil (1998) reported actual yield realized from teak plantations in Nilambur Division during the period 1967 to 1994 based on the data available in the files of the forest department. The MAI ranged from 0.973 to 5.641 m^3 ha^{-1} with the overall mean of 2.854 m^3 ha^{-1} at 53 years.

3.4.8 Productivity and volume estimates of eucalypt

Currently eucalypt species are worked under a rotation of 8 years. In the case of *Eucalypt tereticornis*, the expected yield in the plantations of site quality I with 1,600 trees per ha was 18 m^3 at 8 years (Sharma, 1978). The observed yield was 7.65 m^3 and 2.545 m^3 at 8 years from seedling crop and first coppice respectively (Jayaraman and Chacko, 1997). Based on the felling records of the Kerala Forest Department it worked out to be 5.15 m^3 at 10 years (Jayaraman and Krishnankutty, 1990).

In the case of *Eucalypt grandis*, the expected yield in the plantations of site quality I with 1,660 trees per ha was 36 m^3 at 10 years (Sharma, 1978). The observed yield worked out to be 9.77 at 10 years (Jayaraman and Krishnankutty, 1990).

Chundamannil (2001) worked out the yield of Eucalypt *tereticornis and Eucalypt grandis* together as 6.43 at 8 years. Both the estimates were worked out based on the felling records of the Kerala Forest Department.

3.4.9 Projection of availability of teak wood

The future projection of supply and demand of forest products is essential for the planning and sustainable forest management. The future availability of timber depends on the age structure of the existing plantations, future planting and harvesting policies. Nonetheless, it is possible to project the availability of timber under certain assumptions. In this study, within the scope of the available data, an attempt has been made to project the availability of teak wood up to the year 2000 under different scenarios based on the age structure of the teak plantations.

Options and assumptions

In Kerala, the rotation age for teak generally ranges from 50 to 60 years due to varying growth attainment. Therefore, it was decided to make different projections according to three rotation periods 50, 55 and 60 years.

As regards yield figures used for projection, two options were available. The first option was utilizing the potential yield as per the All India yield table (FRI, 1970) and the other was the average yield as estimated by Jayaraman and Chacko (1997) based on the field measurements made in the number of representative plots belonging to different age and site quality classes covering all the territorial divisions. The projection was attempted based on both the options. The potential yield in Kerala was considered to be the yield referred against site quality III (The lowest potential yield that may suit Kerala conditions). This is because majority of the teak plantations in Kerala were of site quality II or site quality III (Jayaraman and Chacko, 1997). The thinning years considered for the projection of potential yield were 4, 8, 12, 18, 28 and 40 years. In the case of projection of estimated yield, the thinning years of 7, 10, 16, 24, 31 and 35 years were considered according to average thinning years worked out by Jayaraman and Chacko (1997) based on the records of the Kerala Forest Department.

One of the important assumptions made in the projection is that plantations that are felled will be replanted in the subsequent year. It was also assumed that the addition of new teak plantations during the projection period would be negligible. This assumption seemed plausible because there was no land available for extending teak plantations as indicated earlier.

Projection

For the projection purpose, only teak plantations that come under the territorial divisions were considered. The teak plantations belonging to wildlife divisions were not considered for projection because there were no routine managements practices such as thinning, felling adopted in those plantations. The projection of availability of teak wood based on potential and estimated yield are presented from Figures 14 to 19. As regards the projection of availability of timber for the year 2000-01, the area under all the plantations greater than the rotation age were considered felled in that year. This led to the high availability of timber in the year 2000-01. The projected figures reveal one salient feature that the period around 2010 to 2040 will have relatively higher availability of teak wood.

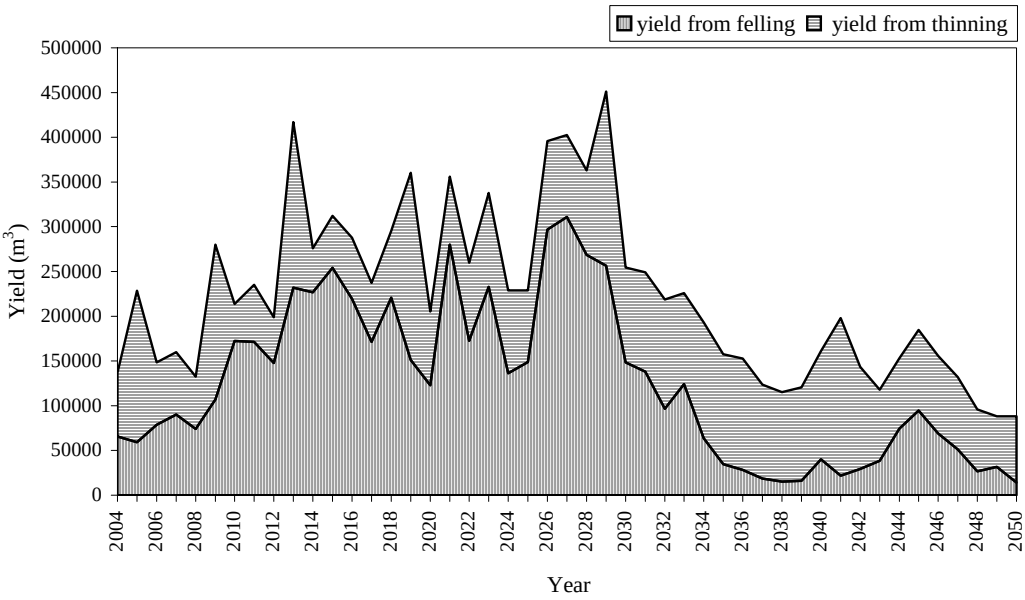


Fig. 14. Projection of potential yield from teak plantations (rotation: 50 yrs)

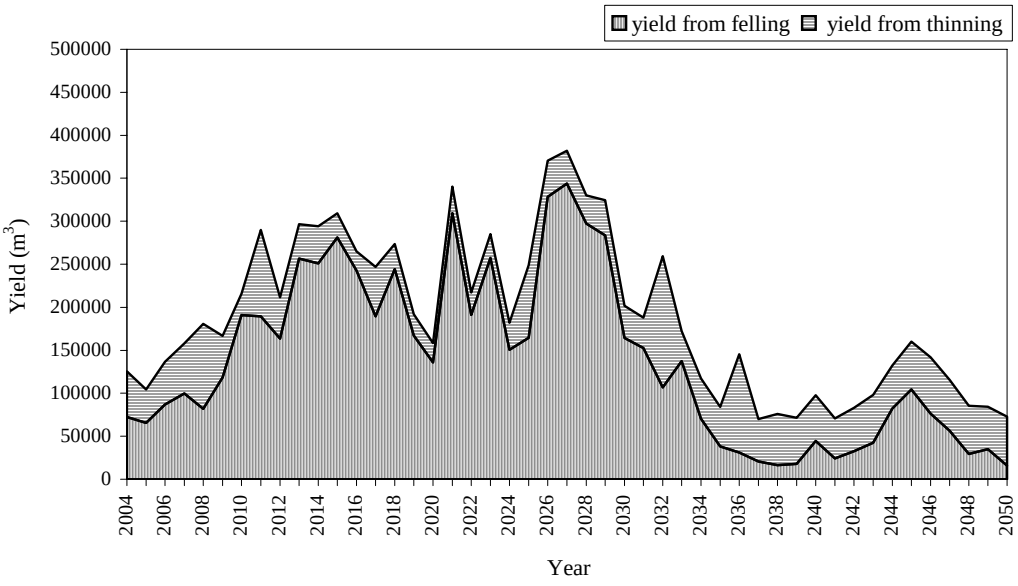


Fig. 15. Projection of estimated yield from teak plantations (rotation: 50 yrs)

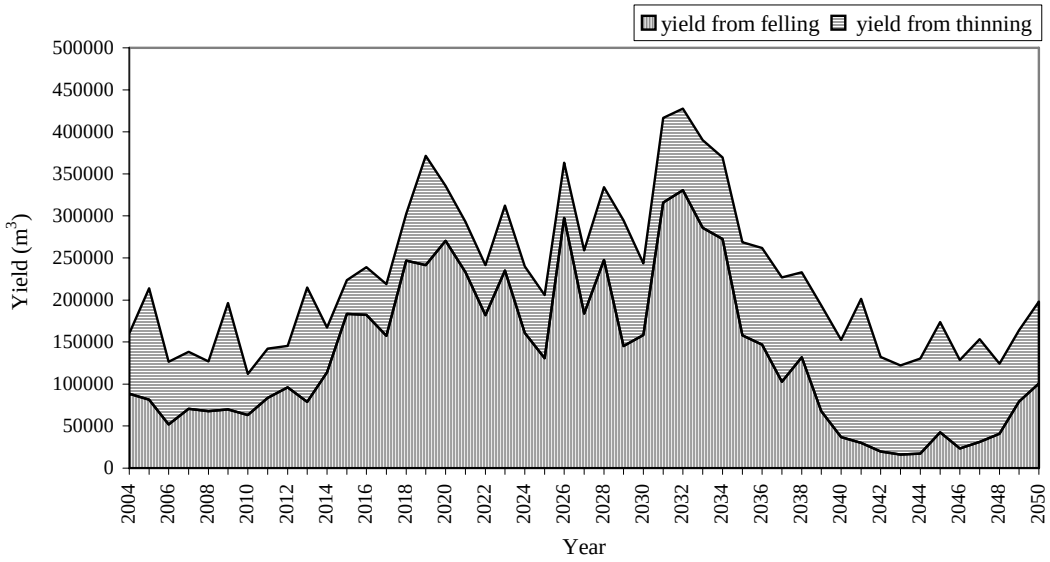


Fig. 16. Projection of potential yield from teak plantations (rotation: 55 yrs)

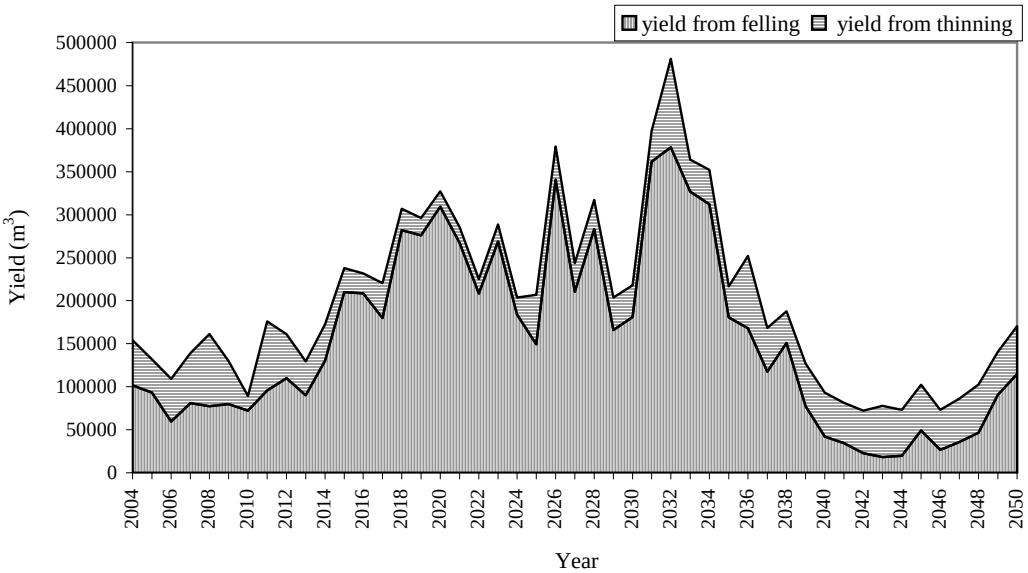


Fig. 17. Projection of estimated yield from teak plantations (rotation: 55 yrs)

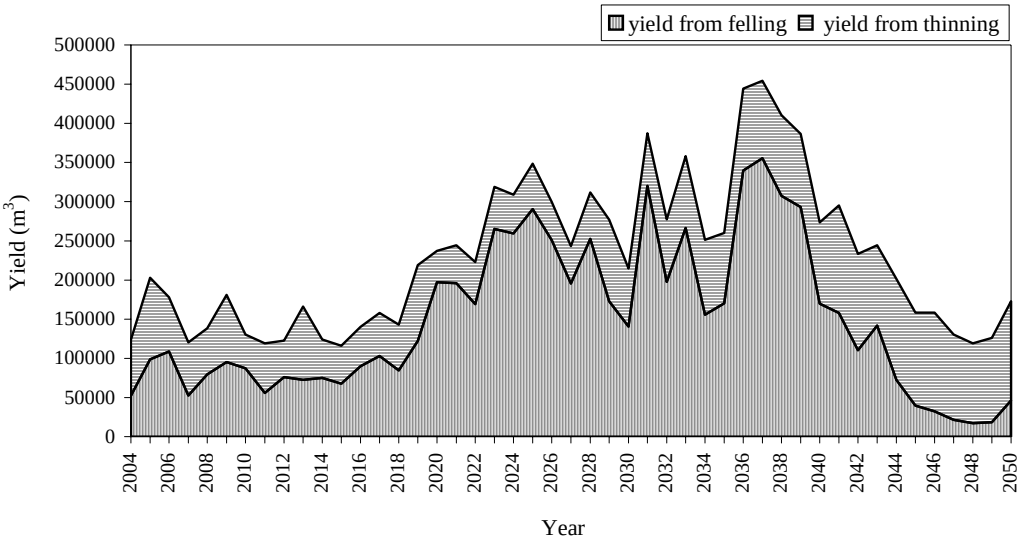


Fig. 18. Projection of potential yield from teak plantations (rotation: 60 yrs)

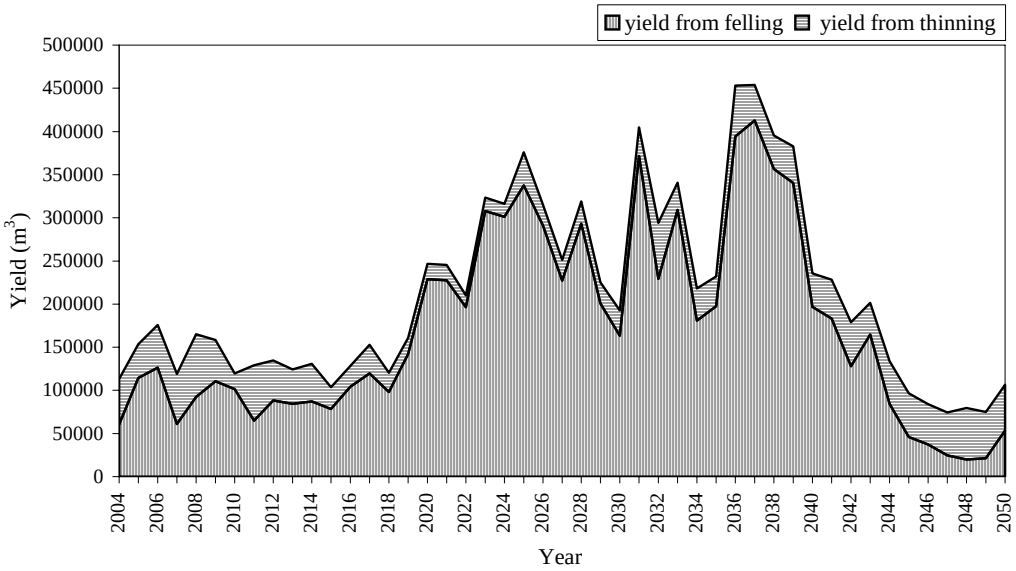


Fig. 19. Projection of realized yield from teak plantations (rotation: 60 yrs)

3. 5 Forest Products

3.5.1 Trends in the production of timber

Teak wood has been contributing the most to the total production of timber in Kerala. For example, during 1999-2000, out of the total round wood produced 96 per cent belonged to teak. The trends in the production of timber have been in tune with the changes in the forest policies from time to time. At present, the production figures of teak categorized according to round wood, sawn wood and poles are available from the Kerala Forest Department for the teak plantations that come under their purview. These figures are only the recorded production. The production of wood (round wood equivalent[1]) from forests shows that the production decreased substantially since 1984 and further accelerated decrease was observed from 1988 onwards due to ban on clear felling and selection felling systems (Figure 20).

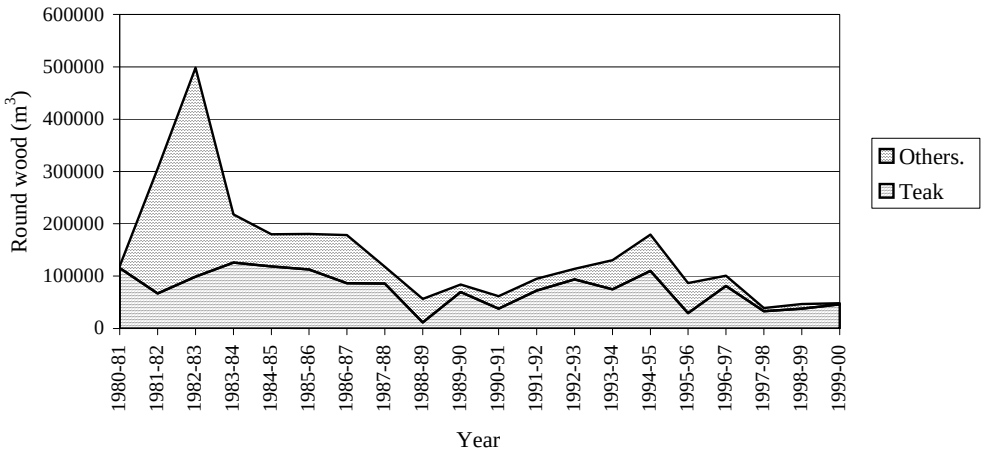


Fig. 20. Trends in the production of teak wood (round wood equivalent[1]) and other species (1999-2000)

[1]The conversion factors adopted for obtaining round wood equivalent are i) 0.85 m^3 sawn wood = 1 m^3 round wood (for teak); 0.75 m^3 sawn wood = 1 m^3 round wood (for species other than teak), ii) 14.1 Nos. of medium sized poles = 1 m^3 round wood (for all species).

Table 13. Trends in the production of timber (m^3) of selected species (1980-81 to 1999-00)

Year	Anjily	Irul	Jack	Maruthy	Thembavu	Venteak
1980-81	3177	13977	218	30339	8857	13975
1981-82	2691	3095	150	10444	3710	6811
1982-83	1549	3061	667	6354	1278	6882
1983-84	1785	1534	135	4773	905	1856
1984-85	495	417	182	3322	394	1931
1985-86	1090	1107	1040	2293	967	2000
1986-87	1642	1544	256	6509	908	2805
1987-88	925	320	61	3195	169	823
1988-89	296	597	20	611	291	500
1989-90	272	1413	66	865	260	561
1990-91	314	449	36	932	107	413
1991-92	526	462	96	238	427	672
1992-93	449	1332	67	2342	446	532
1993-94	381	804	141	2147	264	976
1994-95	2091	742	49	5888	1001	2603
1995-96	336	1160	100	2139	266	763
1996-97	375	1429	79	1381	54	1087
1997-98	45	590	3	460	18	87
1998-99	24	194	2	535	18	75
1999-00	403	1293	1	1432	540	437

3.5.2 Trends in the production of eucalypt

Among the soft wood species, eucalypt constituted the major portion of supply but the whole supply was to "Hindustan Newsprint Limited". The trends in the production of eucalypt from the plantations of KFD are given in Table 14. The production of eucalypt from other public sector undertakings such as Kerala Forest Development Corporation should also be considered to arrive at the State level production figure.

Table 14. Production of eucalypt from forest plantations under KFD

Year	Production (mt)
1992-93	63,318
1993-94	60,970
1994-95	48,837
1996-97	15,691
1998-99	97,379
1999-00	21,167

3.5.3 Trends in the production of selected forest products

The trends in the production of selected forest products extracted by the KFD show that the production of firewood was lesser in 90's than in 80's. There was no charcoal production in recent years. The production of sandalwood was found increased in recent years. The production of bamboo, reeds and ivory showed no trend (Table 15).

3.5.4 Trends in the production of NWFPs

In Kerala, most of the tribal communities depend on the NWFPs for their subsistence and income needs. The tribal population living inside the forest alone is 73,492. In Kerala, there are about 550 species of NWFPs. Medicinal properties are reported for about 500 species of forest plants in Kerala. Out of these about 150 are used in the preparation of medicine on a commercial basis and others are used in the traditional system of medicines and tribal medicine (Muraleedharan *et al*., 1999). The trends in the production of selected NWFP items are given in Table 16. There was no trend in the production of NWFPs over the years. The recorded production presented here would not alone reveal the true picture of production. The illegal collection of NWFPs should also be taken into account while computing production figures of NWFPs from forests. About hundred NWFPs have been notified by the Forest Department. Of these, only twenty to twenty five items are being collected regularly. Bamboos, reeds, canes, cheevakkai (fruit of *Acacia concinna*), kunthirikkam (resin from *Canarium strictum*), honey, pathiripoovu (aril of *Myristica dactyloides*), nellika (fruit of *Emblica officinalis*) are the important products in terms of quantity collected. While bamboo from the forests have been earmarked by the Forest Department, exclusively for the use of pulp and paper industry where as reeds are assigned for the use of both the pulp and paper industry and traditional mat and basket weavers in Kerala. Therefore, these products do not enter the market directly. The Kerala State Federation of SC and ST Development Cooperatives Limited, private traders and tribals (primary collectors) are identified as the three main market agents dealing with NWFPs in the State (Muraleedharan *et al*., 1999).

Table 15. Trends in the production of selected forest products in Kerala (1980-81 to 1999-00)

Year	Firewood ('000 mt)	Charcoal (mt)	Bamboo ('000 Nos.)	Reeds (Lakh Nos.)	Sandal wood (mt)	Ivory (kg)
1980-81	249	554	2,472	241	2	144
1981-82	188	605	895	443	23	12
1982-83	141	9	1,451	234	143	46
1983-84	68	403	48	253	2	49
1984-85	58	488	1,016	431	115	17
1985-86	32	281	414	530	36	100
1986-87	78	26	6,281	267	65	35
1987-88	25	19	4,213	1,098	123	177
1988-89	19	9	374	406	34	3
1989-90	11	5	1,283	765	77	221
1990-91	10	65	3,756	760	72	212
1991-92	17	5	1,006	420	84	229
1992-93	24	1	1,077	416	147	63
1993-94	33	1	1,870	648	218	61
1994-95	83	293	1,596	578	113	3
1995-96	45	0	1,340	415	134	0
1996-97	30	0	4,829	505	104	3
1997-98	11	0	2,338	632	171	2
1998-99	18	0	2,088	627	178	4
1999-00	14	0	628	396	97	30

Table 16. Trends in the production of NWFPs (kg) in Kerala (1985-86 to 1999-2000)

Year	Ayurvedic Herbs	Bee's wax	Fibre	Grass other than fodder	Honey	Incensive Plants	Medicinal Plants	Spices	Vegetable oil seeds
1985-86	548729	11351	12200	1100850	22547	13273		28099	17156
1986-87	132162	1051	74298	525332	14813	18331		45077	21464
1987-88	617633	1030	117	17803	15622	64276	87	626961	20959
1988-89	675058	846	46500	11155	27459	53578	28	207994	22480
1989-90	625751	1160	283.0*	99049*	50214	47790	26	134688	24123
1990-91	170317	1656	14950	61200	16573	17941	58361	199402	4000
1991-92	505881	888	8200	43750	44480	43785	84956	277333	8859
1992-93	768998	1006	10850	16925	38285	135609	17715	113927	22890
1993-94	556021	1561	16300	130100	65655	93179	40777	302361	16932
1994-95	755358	1926	35650	97275	37512	151076	66935	103286	13464
1996-97	842452	2603	11955	28875	72161	114052	36147	163535	6079
1997-98	7089938	1338	75725	25650	71214	73023	32770	236113	3374
1998-99	440829	345	17650	30875	21376	110401	30178	46122	5811
1999-00	887082	986	12410	19500	41734	122214	52646	108221	12168

* in bundles

3.6 Timber Prices

Variation in prices of forest products is one of the main sources of uncertainty in forest planning. The past and future trends of prices of major timber species in Kerala were analyzed in detail by Krishnankutty (2001a and 2001b). His first paper used spline models for describing the past trends for the period 1956-57 to 1993-94 and in his second paper, Autoregressive Integrated Moving Average (ARIMA) models were fitted for forecasting teak prices for different girth classes up to the period 2015-16. In this study, the price figures already collected by Krishnankutty (2001b) could be updated only with un-weighted prices. Because the prices of teak vary greatly by quality classes the weighted teak prices are required for reliable forecasting. Therefore, the forecasting of teak prices was not attempted. The average current prices for major species are given in Table 17. For the prices of other species, the software may be referred to.

Table 17. Species-wise average current prices of selected timber species (Rs.) (1981-82 to 1999-2000)

Year	Anjily	Irul	Jack	Maruthy	Teak*	Thembavu	Venteak
1981-82	2125	1454	1830	1360	3670	1578	1642
1982-83	2632	2218	2157	2247	5180	2207	2419
1983-84	2621	2021	2931	2476	4527	2316	2713
1984-85	2840	2999	3679	2886	5107	2626	3009
1985-86	2875	3041	2260	2468	5873	2181	2817
1986-87	4046	3191	1753	2859	7508	2986	2961
1987-88	3922	2621	3579	2336	7476	2497	2800
1988-89	4513	2689	3000	3102	7251	2826	3046
1989-90	2229	3486	3218	3016	9432	2466	3670
1990-91	2773	3309	2624	3053	9299	3318	3720
1991-92	4422	4015	7481	2726	11352	4260	4374
1992-93	7474	4853	2376	4537	13326	4688	5201
1993-94	8224	6862	7835	6051	15859	3492	6061
1994-95	7666	5846	6388	5302	19482	6879	6559
1996-97	9448	10100	10880	6645	25558	9220	8030
1997-98	10420	10350	11620	7045	26480	10805	8073
1998-99	11175	11390	12790	7755	27693	11890	8200
1999-00	13833	11390	13840	8531	28578	20020	9020

*Teak prices after 1993-94 were un-weighted average prices

3.7 Revenue and expenditure of the Kerala Forest Department

The Kerala Forest Department (KFD) is the major agency, which manages the forests of Kerala. Therefore, its revenue and expenditure pattern has important implications in protecting and conserving forests of Kerala. The net revenue of the department during the period 1999-2000 was 11,327 lakh, which constituted nearly 1.5 per cent of the total revenue of the state government. In general, the net revenue of the department has been increasing over the years. The revenue as on 1998-99 was thrice that of 1982-83. The major source of the revenue was from the sale of timber. As indicated earlier teak timber being the most contributing one to the total supply of timber and also valued higher it may be inferred that sale of teak timber was the major source of income. The next notable source was from the sale of firewood and charcoal (Fig. 21).

The expenditure pattern is usually determined by several factors including the financial position during the year and priorities. The expenditure of the department has always been lesser than the revenue. However, the gap between expenditure and revenue was narrower during 1988-89 to 1992-93 and again in 1998-99. In 1999-2000, the total expenditure was 13,044 lakh, which exceeded the total revenue. During all other years the gap between revenue and expenditure was much wider (Fig. 22). The non-plan expenditure has been the major portion of the total expenditure usually 20 to 40 percent and higher than the plan expenditure. However, in 1998-99 and 1999-2000, the plan and non-plan expenditure were equal (Fig. 23). The trends in forest sector-wise expenditure reveal that there has not been consistent sector-wise expenditure. It varied depending on the time periods. There had been higher expenditure for social forestry sector during the period 1985-86 to 1992-93. The expenditure on this sector greatly declined since then due to its failure. However, in 1999-2000, social forestry has higher allocation than the other sectors. The expenditure on the account of wildlife protection and conservation has been increasing steadily except in 1998-99 and 1999-2000. During the recent years, there has been greater expenditure on the account of general forestry than the other sectors (Fig. 24). The detailed analysis of item-wise revenue and expenditure in each sector would be desirable.

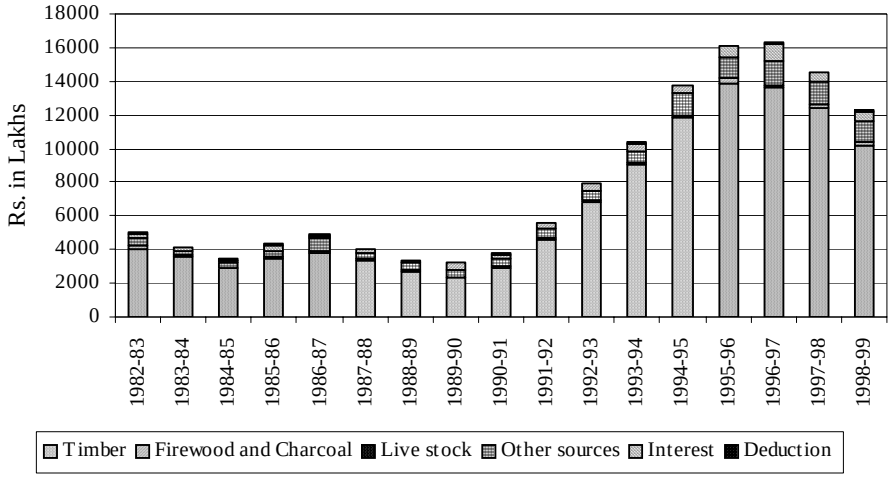


Fig. 21. Trends in revenue of Kerala Forest Department from different sources

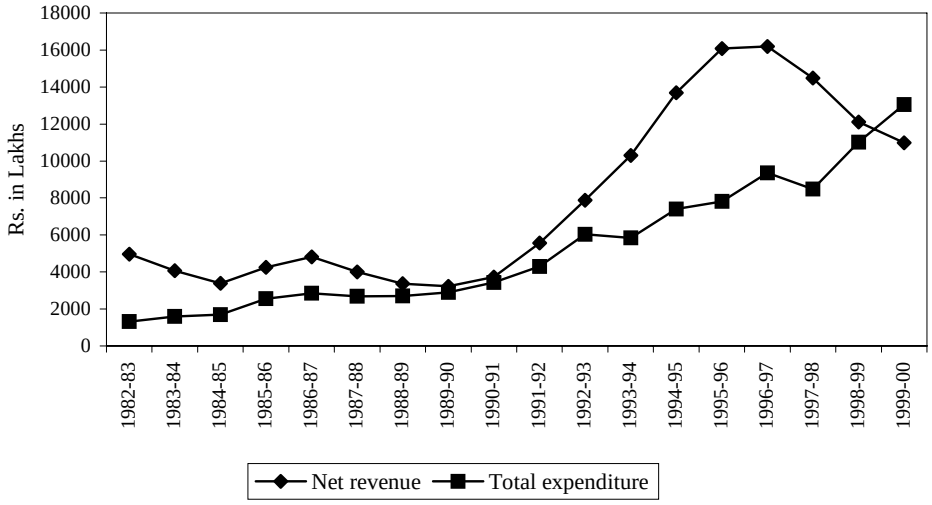


Fig. 22. Trends in revenue and expenditure of Kerala Forest Department

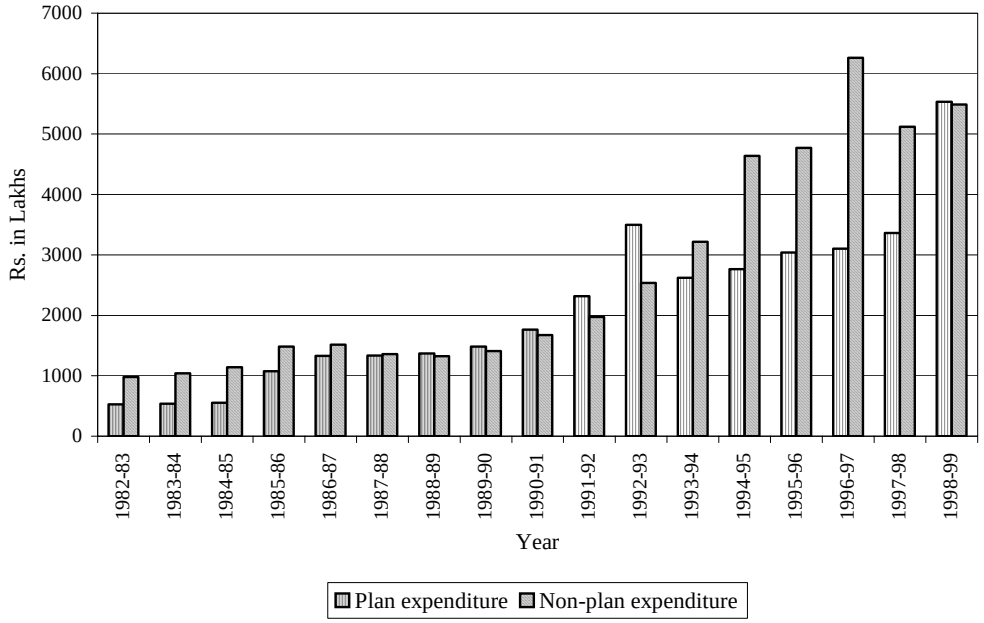


Fig. 23. Year-wise plan and non-plan expenditure of Kerala Forest Department

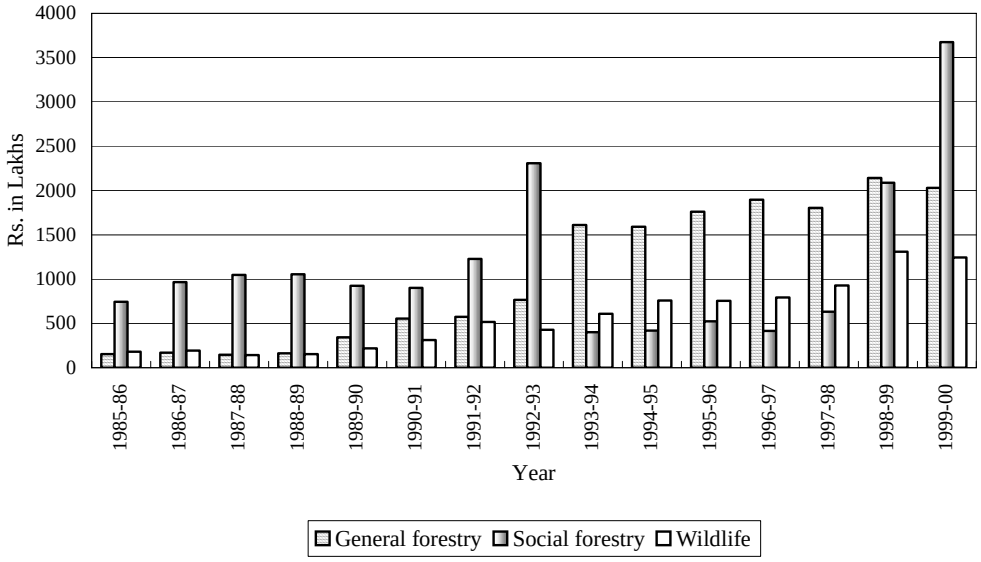


Fig. 24. Trends in sector-wise plan expenditure of Kerala Forest Department

3.8 Forest weather

Continuous recording and dissemination of forest weather will be helpful in formulating management strategies for the development of natural forests and plantations. For example, raising plantations of a particular species will require information on the weather data of a particular area for the successful establishment and optimal growth. The Department of Meteorology, Government of India is the major agency, which supplies more detailed and reliable data for the selected places in Kerala but not for the forest areas. Although the Kerala Forest Department has been collecting rainfall data for the selected forest areas, formally published data have not been available until very recently. The Kerala Forest Research Institute has collected weather data from the selected wildlife sanctuaries for the period 1997-1998 through automatic weather data recording system and the data have been published (Kallarackal and Somen, 1999). The other useful weather data within Kerala are available from the Kerala State Electricity Board (KSEB) and Department of Irrigation for their various weather stations situated all over Kerala. Some of them may represent forests. The rainfall data for the selected rainfall gauges/weather stations situated in various forest divisions/wildlife sanctuaries are presented in Tables 18 and 19.

Table 18. Monthly rainfall (mm) recorded in the rain gauges of the Kerala Forest Department (1999–2000)

Division/Centre	1999								
	April	May	June	July	August	September	October	November	
Thenmala	146.20	410.00	389.60	285.80	89.40	78.00	1207.80	116.20	
Konni	407.00	644.00	790.00	457.00	183.00	124.00	906.00	267.00	
Achencoil	18.50	146.80	134.35	241.50	161.50	101.50	467.20	96.60	
Vazachal	105.50	627.40	694.90	1178.82	403.70	18.66	336.72	43.22	
Chalakkudy	-	-	-	323.00	66.10	18.60	253.95	6.23	
Malayattor	-	-	-	388.00	296.20	112.10	390.00	54.00	
Mannarkad	15.00	40.00	537.00	606.00	169.00	54.00	715.00	15.00	
Nilambur (N)	28.00	374.00	417.70	651.10	316.00	35.00	284.00	41.00	
Kannur	1.07	72.60	123.54	91.87	93.44	34.65	55.12	2.37	
Thrissur	-	-	-	270.93	161.60	34.66	324.60	27.28	
Thekkady	51.00	336.50	200.00	316.50	104.00	70.33	282.00	85.16	
Eravikulam	85.60	48.00	15.80	37.12	15.20	44.10	347.18	258.30	
Silent Valley	93.30	749.80	1568.80	1941.45	1040.00	151.80	751.00	62.65	
Wayanad WLS	58.90	144.00	163.15	435.75	155.00	81.25	258.75	28.92	
Thriruvanan thapuranm WL	272.40	608.00	565.10	355.20	162.00	159.20	930.40	185.20	

Table 19. Monthly rainfall (mm) of selected Wildlife Sanctuaries (1997 and 1998)

	Peechi-Vazhani		Chinnar		Silent Valley		Eravikulam	
Month	1997	1998	1997	1998	1997	1998	1997	1998
January	0.0	0.0	NA	0.0	NA	0.0	NA	0.0
February	0.0	0.0	NA	2.8	NA	0.6	NA	7.8
March	0.0	27.6	NA	0.0	NA	20.2	NA	0.0
April	0.8	18.2	NA	22.1	22.0	45.6	NA	28.2
May	67.6	107.8	NA	15.6	181.8	98.6	NA	3.8
June	518.4	792.2	NA	12.6	587.6	1096.4	NA	1284.1
July	763.6	792.8	0.4	60.4	1615.0	1287.6	NA	1114.4
August	657.0	529.4	10.4	28.3	769.4	609.8	NA	496.8
September	147.0	530.4	29.1	27.1	574.8	563.6	261.0	441.6
October	188.5	474.2	237.4	8.4	95.2	741.4	117.2	511.2
November	240.0	121.2	163.1	0.4	0.0	256.4	4.0	103.0
December	17.6	43.6	80.0	105.2	0.0	69.4	37.0	50.0

NA indicate no data or invalid data

Table 20. Monthly temperature (^{0}C) of selected Wildlife Sanctuaries (1997 and 1998)

Month	Peechi-Vazhani						Chinnar					
	1997			1998			1997			1998		
	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max
January	20.8	25.6	31.7	18.3	26.8	33.5	NA	NA	NA	NA	NA	NA
February	19.8	25.6	33.8	21.5	27.6	35.1	NA	NA	NA	16.1	25.4	34.5
March	22.3	29.1	36.7	22.6	28.8	37.6	NA	NA	NA	14.2	26.6	37.2
April	23.4	29.1	36.5	22.2	30.0	38.4	NA	NA	NA	17.0	28.6	37.8
May	22.4	28.6	35.2	23.0	29.3	36.6	NA	NA	NA	20.1	28.7	37.8
June	22.0	26.7	35.7	22.6	26.2	35.0	NA	NA	NA	20.8	28.5	37.5
July	22.2	25.1	30.7	22.0	25.5	31.4	24.4	28.0	32.0	20.1	26.8	34.1
August	22.0	25.5	31.8	23.2	25.9	31.4	18.7	27.8	34.6	17.6	25.8	33.8
September	22.0	26.3	32.2	22.5	25.3	31.0	17.2	26.3	34.7	18.0	26.6	34.4
October	21.8	26.7	33.3	21.3	25.3	31.4	18.4	24.8	34.0	15.4	25.4	33.7
November	22.5	26.4	32.0	21.0	25.8	32.4	18.4	23.9	29.8	15.0	23.6	30.4
December	21.8	26.7	32.8	19.8	25.4	31.1	17.8	23.4	29.1	13.1	22.2	28.7

Contd…

Table 20 contd…

Month	Silent Valley						Eravikulam					
	1997			1998			1997			1998		
	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max
January	NA	NA	NA	14.8	21.1	27.4	NA	NA	NA	13.1	17.5	27.7
February	NA	NA	NA	15.3	21.4	27.8	NA	NA	NA	13.6	17.4	22.3
March	NA	NA	NA	16.6	23.0	30.6	NA	NA	NA	14.1	19.1	25.6
April	17.3	22.0	29.4	18.8	23.7	31.9	NA	NA	NA	15.3	19.5	23.9
May	18.0	22.1	27.9	19.2	23.3	30.6	NA	NA	NA	15.6	18.8	22.7
June	17.6	20.9	27.2	18.0	20.9	26.5	NA	NA	NA	14.3	16.6	22.4
July	18.0	19.9	24.1	18.0	20.1	25.1	NA	NA	NA	13.0	16.0	20.1
August	17.6	19.8	23.0	17.5	20.3	24.1	NA	NA	NA	13.1	16.3	19.5
September	17.0	20.3	24.5	17.8	20.0	23.6	13.9	16.4	19.6	13.7	15.8	18.9
October	16.5	21.0	26.6	15.6	19.9	23.7	14.6	16.9	20.5	12.5	16.0	18.7
November	NA	NA	NA	14.6	20.0	25.3	14.3	16.7	20.7	13.2	16.1	20.0
December	16.6	21.1	24.6	12.9	20.2	25.4	13.6	17.8	30.7	11.0	15.9	20.8

NA indicate no data or invalid data

3.9 Gaps in the database developed and future directions

The present database was developed within the limited resources available. In future, such an activity should be on a continuous basis requiring frequent updating and publishing. Apart from updating, gaps found in the existing database should also be filled up. The themes that can get focus in the immediate future include

i) Forest maps by vegetation types and region
ii) Status of forest soils in natural forests and plantations
iii) Region specific status of natural resources (including minor forest products, bamboo, rattan) in the forests
iv) Region specific status of biodiversity (flora and fauna) in the forests
v) Demand and supply of wood
vi) Forest based industries in terms of number of units, pattern of consumption, employment, etc.
vii) Information on forest policies and forest management (including Joint Forest Management, Vana Samarakshana Samithies)
viii) Information on tribal population living within and adjacent forests

The database should contain the data as extensively as possible so that they are amenable for statistical and economic analyses to bring out prediction models and useful information, which can be used by the planners and decision makers.

The facility for information retrieval in the existing database software can be improved by including the following.

i) Graphical display of data so as to know the present trend instantly and derive information
ii) Ability to retrieve the required data based on keywords
iii) Ability to print the data and export the data to other software
iv) Facility for downloading the database from internet for wider use and
v) Efficient display of data

3.10 Database on Forest Resources: Sources, Issues and Challenges

The information on forest resources is essential in view of the complex nature of forestry and its contribution to the economic, social and environmental needs of the nation. Though there has been greater emphasis on developing a well-defined forest information system with the use of information technology, we are yet to make concerted efforts on this line. The issues and challenges are although recognized, the experiences gained during the present study while referring to several materials reinforce them.

The major areas of forest statistics collected include i) forest area according to ownership type, legal status, economic management, exploitation and protection; ii) forest areas surveyed, the demarcation and maintenance of forest boundaries; iii) extent of forest plantations under different species; iv) production of timber, firewood and minor forest products; v) prices of forest products; vi) revenue and expenditure of the forest department; vii) employment in forestry sector and forest based industries and viii) foreign trade in forest products.

The detailed information on forests are generally found in the Working Plans of the forest divisions which are prepared for every 10 years. The forest divisions send their data annually to the State Forest Department Head Quarters and the state level data are published in Annual Administrative Reports. The Forest Survey of India, Dehradun generates and publishes considerable data on the extent of different forest types in the Status of Forest Report Series. Central Statistical Organization collects data on forests in order to estimate gross domestic product. The Directorate of Commercial Intelligence and Statistics publishes data on forest products as part of its overall statistics on foreign trade. The National Waste Land Development Board collects data on afforestation, social and farm forestry. The data on forest based industries are provided in the Annual Survey of Industries published by the Industrial Statistics Wing of the Central Statistical Organization. The National Natural Resources Management System of the country, being implemented by the Department of Space is involved in creation, collection and maintenance of large data bank on natural resources and networking them through organized state and district nodes throughout the country (Lakshmi *et al.,* 1998). Data on biodiversity exist at three levels: genetic diversity, species diversity and ecosystem diversity. In situ

conservation at the species and ecosystem levels of diversity fall under the purview of the Ministry of Environment and Forests. The first level (genetic diversity) involves the Department of Agricultural Research and Education, Indian Council of Forestry Research and Education, Department of Biotechnology, Department of Science and Industrial Research and Department of Science and Technology. Data on some aspects of biodiversity are also available from the sources such as Botanical Survey of India, National Bureau of Fish Genetic Resources and National Bureau of Plant Genetic Resources (Khoshoo, 1996). Most important national level statistics on forests are also found in FAO's publications. These are based on reports received from countries. The Centre for Science and Environment (CSE) publishes statistics on environment and related aspects by collecting from different agencies. The various forestry-related Research Institutes around the nation also generate valuable data as part of the research projects.

So, different agencies collect different kinds of information. Some collect information mostly to satisfy their own immediate requirements. The publications of reports from some agencies is often belated and pertain to different time periods and do not satisfy the requirements of the decision makers and those related to forestry. This is mainly because of lack of coordination between the agencies who collect the data and actual user agencies. For instance, some areas of information on forest industry, trade and social aspects may lie outside the immediate jurisdiction of the forest department. It is essential that strong links be made between forest department and other data collecting agencies to share each other data requirements and develop standards to avoid duplication.

The main problem in forestry sector database is the non-availability of sufficient, usable and timely information. For example, we require the plantation-wise details on the site quality, survival status, thinning yield, felling yield, etc. for the reliable projection of timber supply. This is because, in many key areas of forestry sector (like plantation sector), we still follow the age-old pattern of collecting information with huge number of forms, which are very difficult to fill-in. There has not been efforts to revise the data collection, storage and processing and publication procedures in the light of the changed perspective of environment oriented forest management and technological advancement.

The data collection and dissemination activities are critical for management planning activities. However, there are some basic concerns. One is that investment strategies are rarely based on critically analyzed plans aided by strong data. Subsequently, incentives to maintain an adequate planning system are week. Another concern relates to the capacity at the state level to develop and apply analytical techniques with aid in the evaluation of forest management activities. Training the personnel in information technology at various levels of forest management is required so that the modernization programmes would be appreciated and successful, as the trained personnel will realize the benefits of the technology.

A common problem in statistical system in the country is the lack of feedback system. The personnel who actually involve in data collection and data processing should be made known to the outcome and the final publications so that they will realize the utility of their contribution.

Today's forest management requires variety of online information on forestry and its related aspects for effective monitoring of forests. In this regard, there are key issues to be addressed such as i) the parameters to be monitored (biodiversity, soil, protected area, agroforestry, etc.); ii) linkage of monitoring activities at different levels of forest management units; iii) monitoring techniques and practices for comprehensive, continuous and compatible forest information (World Bank, 1993).

It has often been recommended that statistics of forestry sector should be brought together in a centralized system covering all aspects including forest resources, forest products, industry, trade and social and environmental aspects. However, to develop an effective system, concerted efforts have not been taking place. This can not be a simple endeavor given the widely interrelated nature of forestry sector. It is high time that all who concerned with the forestry join together and hold series of consultations to come out with a unified system using modern information technologies (including Geographic Information System and Remote Sensing Technology) and appropriate institutional mechanism to implement such a system.

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