Project Report

CARRYING CAPACITY BASED DEVELOPMENTAL PLANNING FOR GREATER KOCHI REGION

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Introduction

Increasing population has put pressure on the land which is a limited resource. Planning for development of any region has to identify, restore, maintain and enhance the quality and quantity of the natural resources in the region which provide goods and services for the well being of species and mankind.

The ability of the system to produce desired outputs (goods and services) from a limited resource base while maintaining desired environmental quality level in the planning region is a major challenge. The trade-off is between the desired production-consumption levels through the exploitation of supportive capacity and environmental quality within the assimilative capacity of the regional ecosystem. Assimilative capacity is the maximum amount of pollution load that can be discharged in the environment without affecting the designated use. Supportive capacity is the maximum amount of resources that can be extracted without impairing the ecological integrity or regenerative capacity. For human society, carrying capacity can be defined as the maximum rate of resource consumption and waste discharge that can be sustained indefinitely in a defined planning region without progressively impairing bio productivity and ecological integrity. The supportive and assimilative capacities can be enhanced through technological, managerial and organizational interventions.

Evaluation of the forest sector to estimate its ability to produce desired outputs (goods and services) and achieve equitable quality of life levels with trade offs maintaining desired environmental quality levels in the study area is the major goal of the proposed study.

1. SUPPORTIVE CAPACITY

It has been undoubtedly established that the tropical evergreen ecosystem is the most complex and diverse ecosystem of the planet earth. Moreover the ecological function and processes is an integral part of the very existence of life including human beings, on earth. A rich array of species and a complex web of interactions make a system much more fragile and sensitive (May, 1975). A forest ecosystem as natural capital also provides a wide spectrum of ecological, social and cultural benefits through its diverse components, various processes and multiple functions (Table 1). Ecosystem functions include enhancement of productivity, retention of biodiversity, carbon sequestration, assimilation of pollutants, nitrogen fixation, amelioration of microclimate etc. Watershed functions include soil and water conservation, minimising soil erosion, regulation of stream flows, agricultural productivity, ground water recharge, regulation of floods and droughts, hydroelectric and irrigation projects etc. Protected Areas help in the conservation of rare, threatened, endemic and endangered flora and fauna, facilitating tourism, recreational activities, education and research.

Table 1. Environmental services provided by forests

Services	Category
Ecosystem function	Productivity Biodiversity Carbon store Assimilation of Pollutants Nitrogen fixation Amelioration of microclimate
Watershed function	Soil conservation and reduced soil erosion Regulation of stream flows Agricultural productivity Ground water recharge Regulation of floods and droughts Hydroelectric and irrigation project
Biodiversity	Species and interactions Endemic, endangered, rare and threatened flora and fauna
Livelihood support system	Forest dwellers
Tourism	Ecotourism Recreational activities
Education & Research	Nature education Enhancement of knowledge
Potential future use	The relicts of climax vegetation Remnants of evolutionary process
Services unknown	Goods and services as at undiscovered which cannot be valued on present society's knowledge, skills, needs, technology and uses

Forests also serve as a livelihood support system of forest dwellers. As the relicts of climax vegetation, as remnants of the evolutionary process and its potential capacity to meet the needs, technology and uses in future or in other words unknown services that the forests may provide in future, as at undiscovered based on present society's knowledge, skills, needs, technology and uses, the very existence of forests offer immense scope. Hence conservation of forest ecosystems play a vital role in the developmental planning of the region.

Besides these services, goods provided by the forests have beneficiaries with a wider network. Goods can be broadly categorised into two timber and Non Wood Forest Produce (NWFPs) (Table 2). The major categories of timber such as industrial wood plywood, match wood, bobbin wood etc, are raw material for various industries, to form an array of end products providing employment to thousands of people.

Non Wood Forest Produce (NWFPs) include all goods of biological origin derived from forests excluding wood in all its form. This include fuelwood, fodder, green manure, litter, grass etc, edible products like fruits, nuts roots, tubers, honey, meat etc, industrial raw material such as bamboo, reeds, canes, gums, resins, charcoal etc and as raw material for ayurvedic medicine and cosmetics. Besides NWFPs serve as a source of income and employment generation to indigenous communities, farmers, industrialists, ayurvedic drug manufacturers etc, and as a source of energy input to agroecosystems.

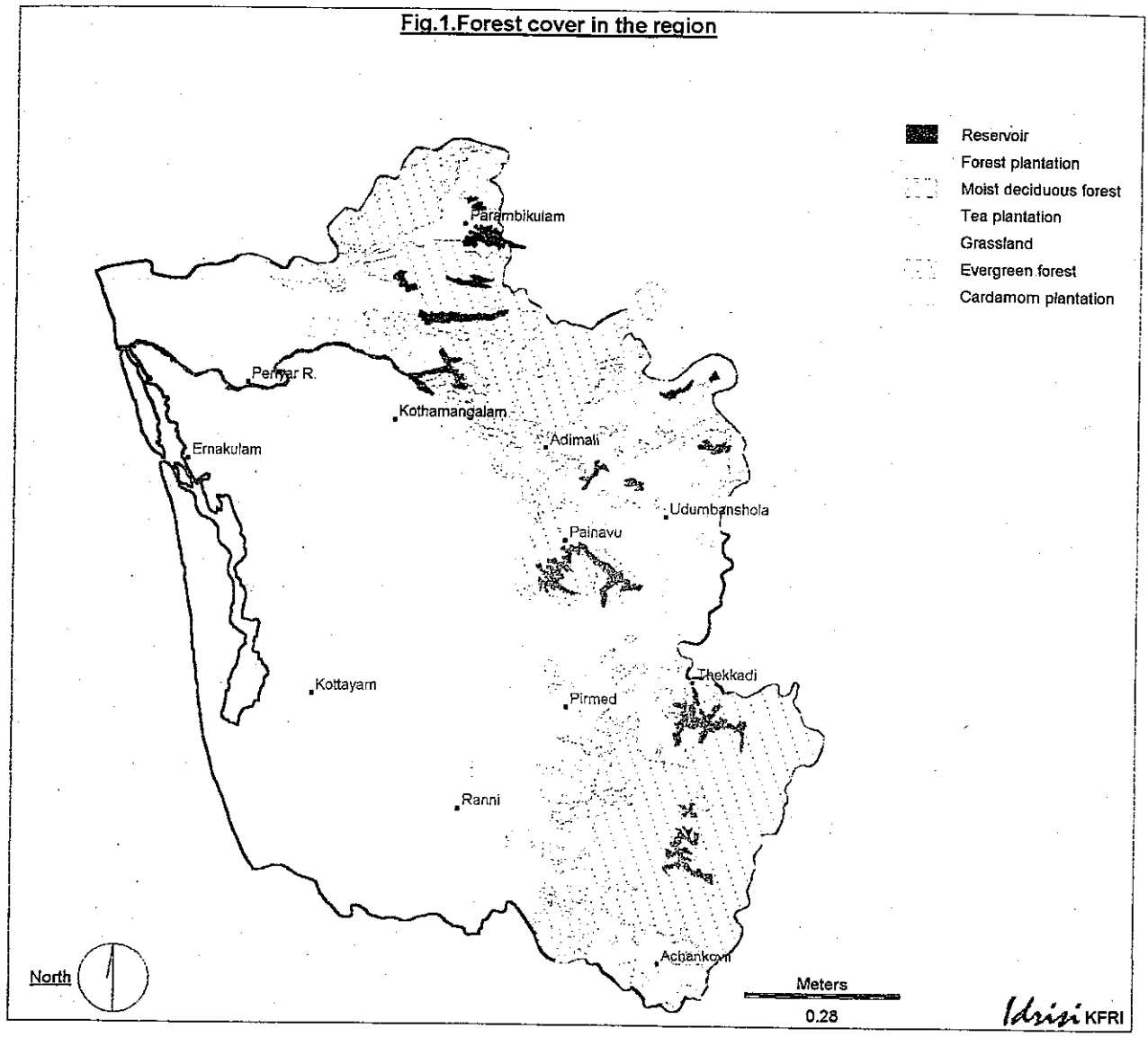
Table . 2 Goods offered by forests

Item	Category	Benefits	Beneficiaries
Timber	Industrial wood Ply wood Match wood Bobbin wood Pencil wood Packing case wood Pulp wood Wood for agriculture implements railway sleepers and coaches temporary construction furniture and paneling fiber board and particle board etc.	Raw material for various Industries Employment Variety of end products	Industrialists End users
Non Wood Forest Produce (NWFPs)	Fuel wool Fodder Green manure Leaf litter Poles Grass (Oil) Medicinal plants Edible products Fruits Nuts Root Honey Meat Industrial raw material Bamboo Reeds Canes Gums and Resins Charcoal Others	Livelihood of forest dependent communities Rawmaterials for Ayurvedic medicines cosmetics, industry, etc. Employment generation Energy input to agroecosystems	Indigenous communities Farmers Industrialists Merchants Ayurvedic drug manufacturers End users Others

1.1. Evaluation of forest sector in the study region

Evaluation of the forest sector is to identify the quality and quantity of the forest cover to provide environmental goods and services as a basis for supporting the population to maintain or enhance the quality of life in the region.

Fig.1.Forest cover in the region

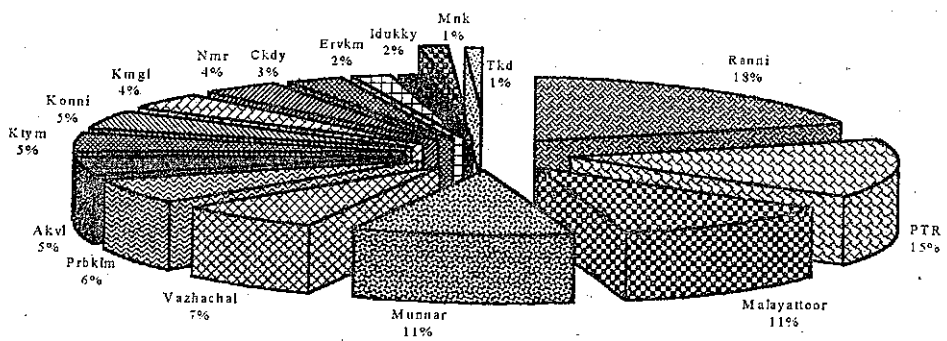


1.1.1. Forest cover

A Forest cover map of the region was generated using IRS 1B LISS II geocoded imagery of 1996. After ground truthing it was reduced to 1:250,000 and super imposed over the base map which was collected from CESS. This map was scanned and subsequently digitized using the On-Screen Digitizing (OSD) facility available in the GIS software IDRISI 2. Areas under different vegetation types were estimated using a digital planimeter and were classified as dense, with more than 40 per cent crown density and as degraded with less than 40 per cent (Fig. 1).

The forest cover of the study region is estimated to be 4168.94 Km^2. This accounts to 29.7 per cent of landuse in the study region. Areas with forest cover in the region are categorised under forest divisions. The major chunk of the forest divisions of Periyar Tiger Reserve (PTR), Ranni, Malayattoor and Munnar which contribute 55 percent of the total forest cover in the region. The contiguous forest patch of Ranni, PTR and Achenkoil contribute 38 percent (Fig. 2).

Fig. 2. Distribution and extent of forest cover in the region



Ranni, Periyar Tiger Reserve, Malayattoor, Munnar, Vazhachal, Prkm-Parambikulam, Ackl-Achenkoil, Ktym-Kottayam, Konni, Ktml-Kothamangalam, Nmr-Nenmara, Ckdy-Chalakudy, Ervkm-Eravikulam, Idukky, Mnk-Mankulam, Tkd-Thattekkad

1.1.2. Vegetation type and status

Area under forests in the study region comprise of the following dominant vegetation types. Evergreen, semievergreen, moist deciduous, montane subtropical and temperate forests etc and forest plantations. Most dominant vegetation is of evergreen and semievergreen type which constitute 65 per cent of the forest cover.

Of this 59 per cent are under dense forests and 41 per cent are degraded. A lion share of the most fragile, biodiversity rich evergreen forests of the State (68 percent) is also being represented from this region.

Moist deciduous forests occupy 16.9 per cent. Of this 76 per cent are degraded. Dense forests under this category constitute only 24 per cent. Montane subtropical and temperate forests constitute 0.1 per cent of which 55 per cent are classified as dense forests. Grass lands constitute 1.93 per cent and forest plantations constitute 16.29 per cent. Area wise estimate of the vegetation types and categories in each forest division is given in Table 3 and distribution of major forest types is given in figure 3. Dense montane subtropical and temperate forests confine to the forests of Mankulam and Eravikulam divisions. Grass lands form the major vegetation type in Eravikulam which constitute 67 per cent of the total grass lands in the study area.

Fig. 3. Distribution of forest vegetation types in the region

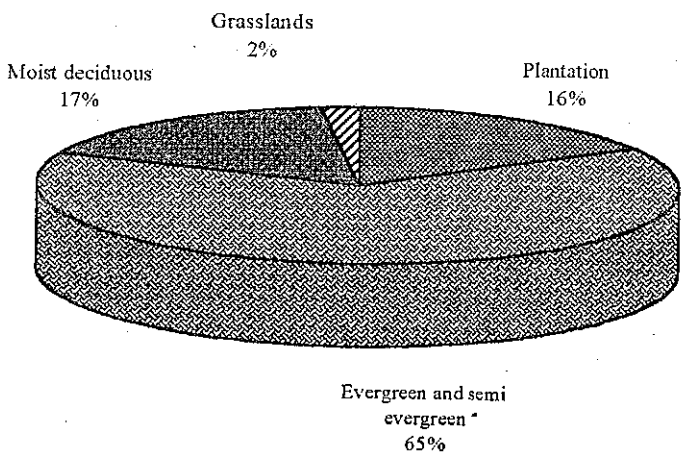


Table. 3 . Area under various vegetation types

Division	Forest Planta-Tion	EG/ SEG (Dense)	EG/ SEG (Degra-ded)	MDF (Dense)	MDF (Degr-aded)	MST/ TF (Dense)	MST/ TF (Degr-aded)	Grass land	Total Km^2
Parambikulam	102.02	29.65	72.17	17.04	23.43	--	--	--	244.31
Nenmara	16.13	2.95	85.48	16.01	40.02	--	--	--	160.59
Chalakkudy	7.04	49.69	8.91	20.36	25.38	--	--	--	111.38
Vazhachal	68.66	204.14	15.83	3.45	6.94	--	--	--	299.02
Malayattoor	70.12	220.22	84.72	23.16	78.80	--	--	--	477.02
Kothama-ngalam	40.63	47.18	60.34	--	33.57	--	--	--	181.72
Mankulam	--	32.11	16.52	--	4.23	2.02	--	--	54.88
Munnar	33.86	189.23	99.46	21.69	94.19	--	--	7.54	445.97
Eravikulam	--	18.96	--	--	2.73	0.50	--	54.08	76.27
Kottayam	47.76	20.44	77.86	2.98	49.82	--	--	--	198.86
Idukky	--	10.39	37.95	--	10.11	--	--	7.94	66.39
Thattekkad	6.08	1.52	17.69	--	9.26	--	--	--	34.55
PTR	78.79	336.07	167.78	31.84	10.16	--	--	4.40	629.04
Ranni	56.06	399.27	262.88	25.96	42.88	--	--	4.98	794.06
Konni	71.96	--	34.19	--	84.33	--	--	--	190.48
Achencoil	80.01	34.57	62.27	6.31	19.56	--	--	1.68	204.40
Total	679.12	1596.39	1104.05	168.80	535.41	535.41	2.52	80.62	4168.94

1.1.3. Growing stock

Total growing stock in the region is 499.18 LM^3. Lion share of the growing stock of wood in the region is in the evergreen forests with majority being represented from Ranni, PTR, Malayattoor, Munnar and Vazhachal. Table 4.

Table 4. Growing stock of wood in each vegetation type

Sl. No.	Forest Division	Plantations (LM^3)	Evergreen (LM^3)	MDF (LM^3)
1.	Ranni	1.96	99.33	6.88
2.	PTR	2.76	75.58	4.20
3.	Malayattoor	2.45	45.74	10.11
4.	Vazhachal	2.40	32.99	1.04
5.	Munnar	1.19	43.31	11.56
6.	Kothamangalam	1.42	16.13	3.36
7.	Chalakkudy	0.25	8.79	4.58
8.	Achankoil	2.81	14.53	2.59
9.	Parambikulam	3.57	15.27	4.05
10.	Mankulam	--	7.30	0.42
11.	Kottayam	1.67	14.75	5.28
12.	Eravikulam	--	2.84	0.27
13.	Idukky	--	7.25	1.01
14.	Nenmmara	0.56	13.27	5.60
15.	Konni	0.21	2.89	0.93
16.	Thattekkad	2.52	5.13	8.43
	Grand Total	**23.77**	**405.10**	**70.31**

*LM^3 – Lakh Cubic Meters

1.1.4. Forest Degradation

Of the total forest cover of 4168.94 km^2 in the study region, 57.6 per cent are degraded forests with less than 40 percent crown density. A significant proportion of degraded forests lie in Nemmara, Kottayam, Idukky, Thattekad, Konni, Achenkoil and Kothamanagalam forest divisions.

1.1.5. Forestry

Forestry in Kerala has a very long history since 1840s. Traditionally production of wood has been the major objective of forest management. Later the attention of forest management turned to forest conservation, ecological balance, ecorestoration, recreation, multiple use management and finally to biodiversity conservation, ever since the Forest Conservation Act, 1980 regulated forest land use decisions. Ban on clear felling with effect from 1982 and ban on selection felling from 1987, has restricted the harvest of timber to activities like removal from mature plantations, wind fallen and dry standing trees and bamboos and reeds from natural forests and occupied lands which are not revertible. Of the timber harvest a lion share, about 80 percent, is attributable to teak.

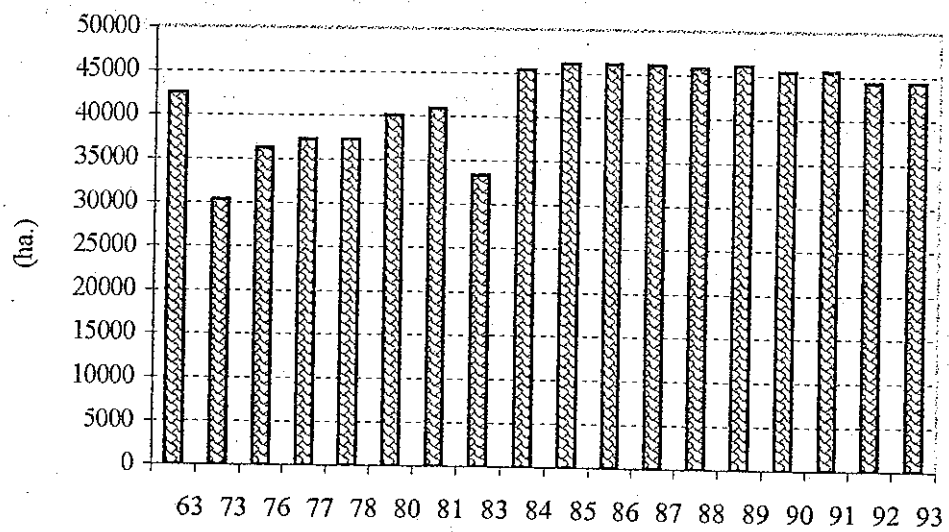
1.1.5.1. Forest plantations

Forest plantation in Kerala are government owned and Forest Department manage the forest plantations. Establishment of new plantations at the cost of natural forests has been curtailed since the ban on clear felling. Hence enhancing the productivity of the existing plantations and maintenance of production of wood over successive rotations are of serious concern and assumes great importance. But unfortunately plantations in Kerala are of low productivity. This is reflected by the Mean Annual Increments (MAI) and the site quality class categories. The MAI of the standing crop of the State at 60 years is 2.423m^3ha^{-1} in comparison with the potential MAI of 4.968 m^3ha^{-1} under site quality class 1 with full stocking as reported in the All India yield table for teak (KFRI, 1997). Site quality is also an important factor. 86 percent of teak plantation in the state fall under medium site quality classes. Difference in site quality results from wrong site selection, planting in steep slopes, lack of water and soil conservation measures, delayed

planting etc. A survey of teak plantations in Kerala reveals decline of site quality in all age groups up to 60 years (Jayaraman, 1995). The age class distribution of teak plantations (Jayaraman and Krishnankutty, 1990) reveals that most of the plantations are of over 30 years planted after 1960. The five year plan targets with over 50,000 ha. of teak plantations on an average annual planting target of 1700 ha has persuaded the Department to go for large scale conversion of natural forests to low productive plantations through unscientific management practices.

Large scale of area of land has been converted into teak plantations during the year 1978-1983, which has stabilised in 1991, later showing a decreasing trend. Data for the study area are collected from 1976-1993 to show the trend from the published sources of Kerala Forest Department (Figure 4).

Fig. 4. Growth in teak plantations in the study area



1.1.5.2 Sector wise expenditure and revenue from timber and other forest products

Expenditure on forests since 1980 till 1994 was collected from the published sources of the Kerala Forest Department. Revenue from timber and other forest products were also collected since 1984 till 1994. Details are given in Tables 5 and 6. The major income of the Department was derived from timber while expenditure on establishment was the highest.

Timber is the major source of revenue, accounting for 87.84% of the total revenue during the year 1993-1994. There is an increase in revenue generated from all the sources during the year 1993-94.

Timber is the major source of revenue attributing to 80 percent of the total revenue. Other sources are fuel wood and charcoal, livestock and other items. Revenue has increased considerably since 1993 and during 1995-96 gross revenue was Rs. 161 crores. The activities under which the expenditures are met are maintenance of existing reserve forests, regeneration, social forestry, wildlife, establishment and other related activities. There has been an hike in the expenditure for the various activities since 1980s which has stabilised since 1993. Expenses on the establishment was the highest followed by the maintenance of existing reserved forests.

Table 5. Revenue from timber and other forest products (in lakhs)

Sl. No.	Item	84-85	85-86	86-87	87-88	88-89	89-90	90-91	91-92	92-93	93-94
1.	Timber	2859.80	3463.24	3782.34	3356.93	2738.33	2308.84	2962.57	4631.11	6794.63	9043.50
2.	Fuel wood and charcoal	73.51	92.06	91.25	--	71.25	44.64	53.56	65.55	89.30	100.89
3.	Live stock	0.62	0.95	0.80	98.23	--	--	--	1.40	1.48	7.63
4.	Other items	329.45	362.66	802.53	365.05	384.97	479.02	484.35	593.54	654.02	683.84
	Total	3263.38	3918.91	4676.92	3820.21	3195.45	2832.50	3500.48	5291.60	7539.43	9835.76
5.	Other receipts including interest in forest area	138.51	361.63	185.20	194.32	183.55	392.87	242.14	286.17	348.68	483.45
6.	Total A+B	3401.089	4280.54	4862.12	4014.53	3379.00	3225.37	3742.62	5578.31	7888.11	10319.21
	Deduct	10.25	25.67	37.31	9.79	4.57	9.12	9.66	14.62	16.72	23.37
	Net Amount	3391.64	4254.87	4824.81	4004.74	3374.43	3216.25	3732.96	5563.69	7871.39	10295.84

Source: Kerala Forest Statistics 1994: Published by Kerala Forest Department

Table 6. Sector wise expenditure on forests (in lakhs)

Year	Maintenance of existing reserve forests	Regeneration	Social forestry	Wild-life	Establishment	Others	Total
80-81	387.93	139.64	7.34	16.08	385.60	83.83	1220.50
81-82	729.82	142.26	8.36	47.53	487.09	108.65	1523.71
82-83	543.46	123.93	15.43	18.27	510.15	100.47	1311.71
83-84	546.83	44.92	238.59	19.05	584.64	166.94	1600.97
84-85	549.79	20.24	231.09	23.04	660.28	153.64	1692.08
85-86	593.43	6.04	667.93	172.75	695.66	427.14	2562.95
86-87	762.12	5.44	672.10	152.75	877.57	173.63	2843.61
87-88	566.62	3.86	945.22	118.34	950.72	107.33	2692.09
88-89	408.35	9.11	931.93	126.62	1050.49	167.61	2694.11
89-90	1217.88	67.55	705.53	209.50	1213.74	520.55	2893.65
90-91	494.58	120.66	616.88	233.84	1511.69	463.29	3440.94
91-92	215.69	125.72	1033.62	454.36	1600.51	861.84	4291.74
92-93	260.97	139.05	1139.68	474.72	1787.77	2233.54	6035.73
93-94	1171.39	167.03	146.51	516.47	2033.78	1829.31	5864.49

Source: Kerala Forest Statistics 1994: Published by Kerala Forest Department

Table 7. Annual turn over from forestry operations (Rs. In crores)

Year	Gross revenue (Rs. In crores)	Expenditure (Rs. In crores)	% share from timber	Turn over
1984-85**	33.92	16.92	84.30	17.00
1985-86**	42.55	25.63	81.40	16.92
1986-87**	48.25	28.44	78.40	19.81
1987-88**	40.05	26.92	83.80	13.13
1988-89 *	33.74	26.94	81.10	6.80
1989-90*	32.16	28.94	71.80	3.22
1990-91*	37.33	34.41	79.40	2.92
1991-92*	55.64	42.92	83.20	12.72
1992-93*	78.71	60.36	86.30	18.35
1993-94*	102,96	58.64	87.84	44.32
1994-95*	136.88	74.28	--	62.60
1995-96*	160.76	61.27	--	99.49

** Only selection fell
* No fell

Ban on clear fell or selection fell has not affected the annual turn over or the share of timber in all revenue from operations (Table 7). There has been considerable increase in the turn over since 1993. It has almost reached 100 crore mark in the year 1996.

1.2. Resource extraction

1.2.1. Extraction of Timber

Important tree species extracted for timber are Teak, Rosewood and Anjily. Over 60 tree species are used to meet the requirements of plywood, matchwood, bobbin wood, pencil wood, packing cases, pulp wood industries etc.

Major sources for pulpwood are bamboo, eucalypt and reed. Data on extraction of bamboo since 1976, eucalypt since 1986 and reed since 1977 till 1993 were collected .

Timber extraction from the study area was compiled from the published sources of Kerala Forest Department. Data was collected during the period 1976-1993 with emphasis since ban on clear felling (1982) and selection felling (1986) (Fig.5 & 6).

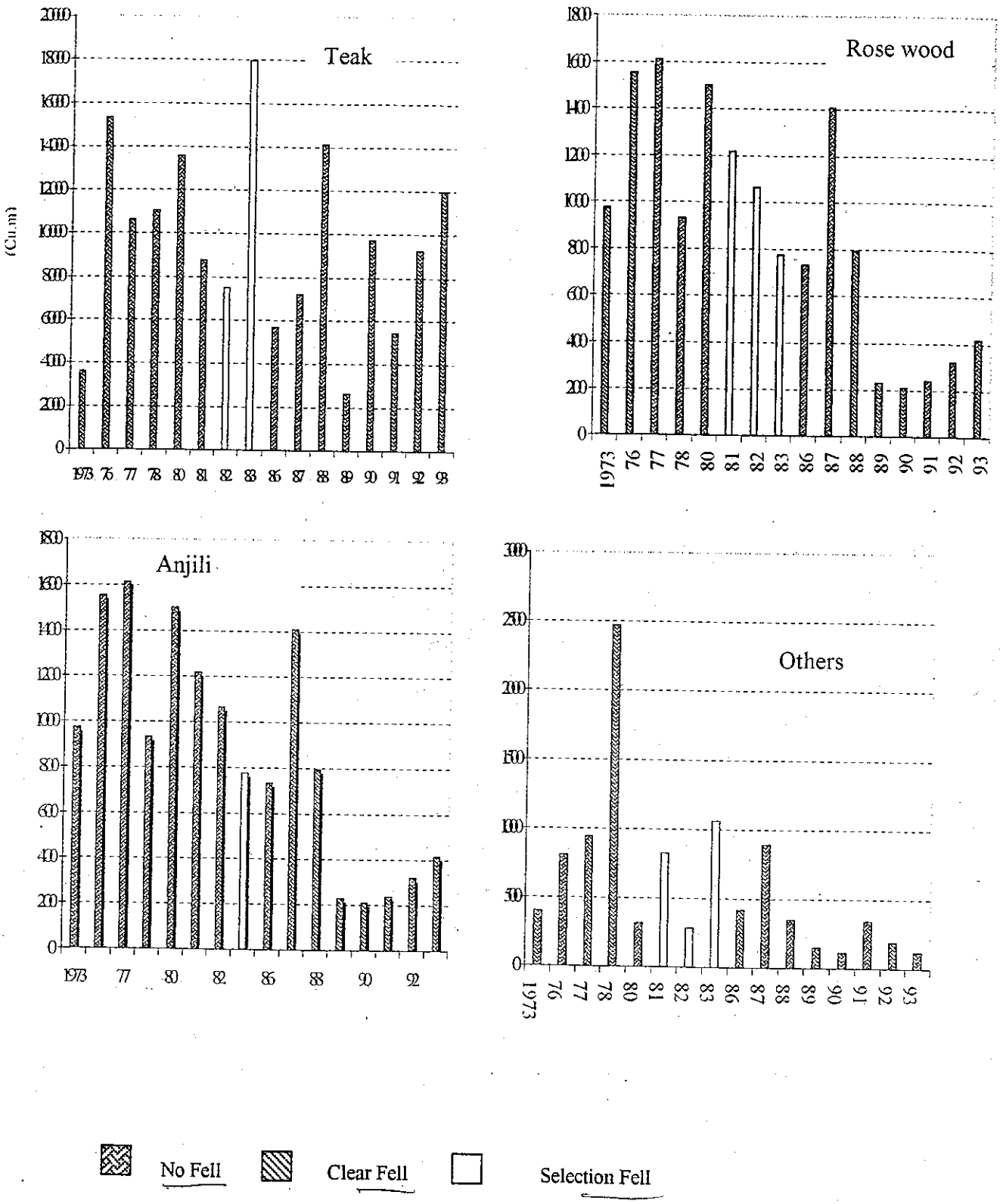


Fig. 5 Extraction of timber from the study area

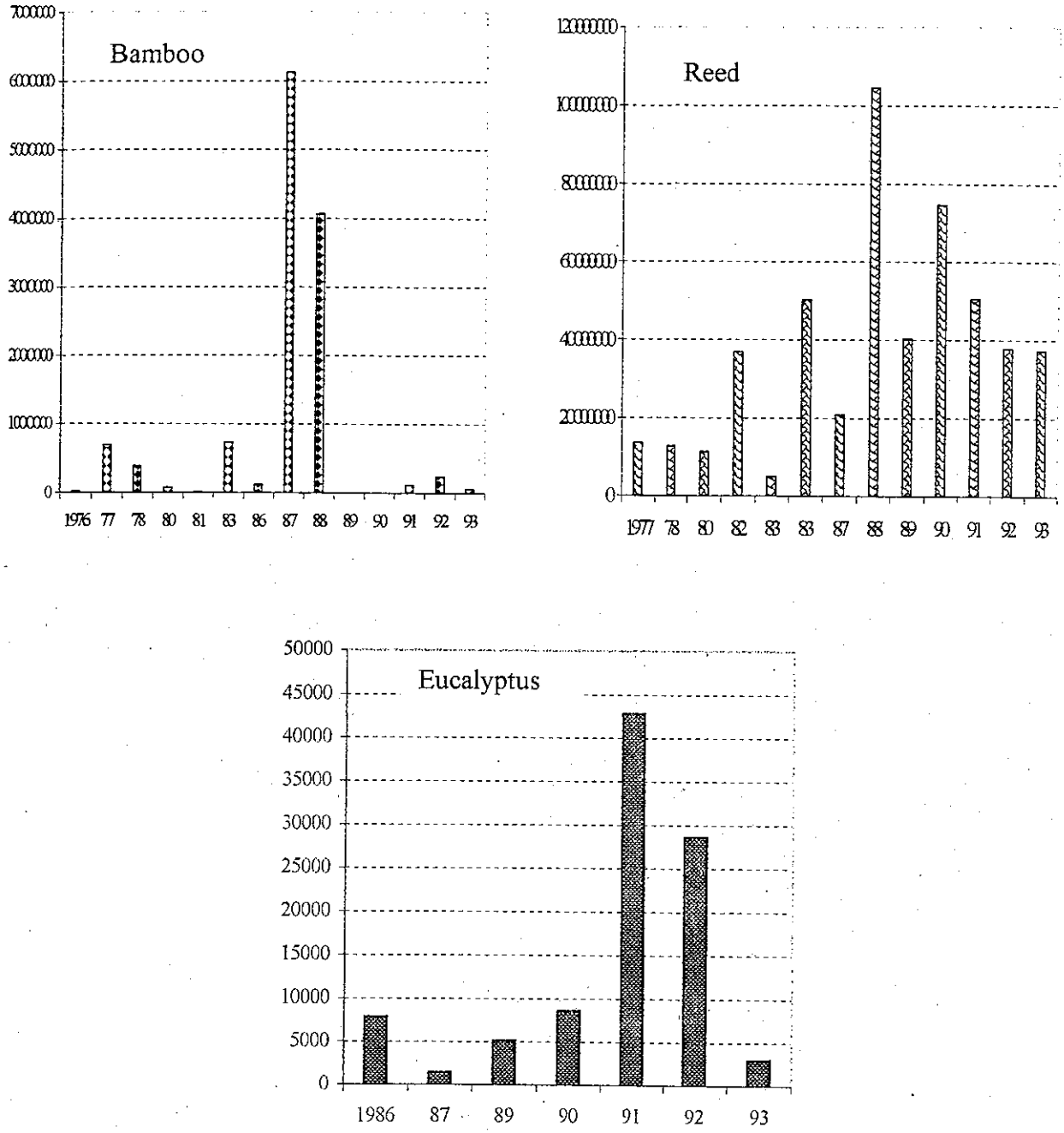


Fig.6. Extraction of major pulpwood species from the study area

Ban on selection felling has witnessed a reduction in the flow of Rosewood, Anjili (*Artocarpus hirsutus*) and other species. There has been no significant difference in the flow of teak. Among the pulpwood species there has been a considerable increase in the extraction of reed since 1987. There has been large scale extraction of bamboo during 1987 and 1988 and eucalyptus during 1991 and 1992 for pulpwood.

1.2.2. Extraction of Non Wood Forest Produce (NWFPs)

The emerging concept of managing forests for Non Wood Forest Produce (NWFPs) has revolutionized the whole approach of sustainable forest management. Importance of NWFPs as an effective tool in forest management has been widely recognised and the stress on the need for its conservation has been identified by many workers **(Hall and Bawa, 1993)**. Till recent past, logging or farming operations were believed to be the major source of income from tropical forests, while studies throughout the world have revealed NWFP as the most potential source of income. Trade in NWFP was found to be more profitable than timber harvesting, managing plantations, cattle ranching any other forestry operation or alternative land use. **(Peters *et al*, 1989., Balick and Mendelshon, 1992, Jahinge *et al*, 1993)**. The extraction of these resources can provide tangible benefits to the local people simultaneously conserving the biological resources of standing forests, which in turn ensures other invaluable infinite and indirect benefits of the forests.

While economic analyses on tropical forests have focused on timber harvesting overlooking the value of Non Wood Forest Produce (NWFPs), we attempt to demonstrate that sustainable harvesting of these resources may provide significant benefits to local people while simultaneously conserving the biological resource of standing forests.

Non Wood Forest Produce (NWFPs) have attracted the attention of resource managers recently. This was mainly due to the following reasons. First, deforestation and encroachments threatened the very existence of NWFP. Second, NWFPs play a vital role in the rural economy and the indigenous societies depend on them or their subsistence and cash income. Third, role of indigenous communities, possessing traditional knowledge, in conserving biodiversity was widely recognized. Finally, NWFP is assumed to be the potential source of new genes and new products or agriculture and pharmaceutical industries **(Hall and Bawa, 1993)**.

Scientists from tropics, repeatedly argue NWFP as the most potential source of income and highlights the importance of managing forests for NWFPs. Trade of NWFP in local markets in Equitos, Peru was more profitable than timber harvesting or cattle ranching in the same area **(Peters *et al*, 1989)**. High value of medicinal plant sales in Belize **(Balick and Mendelsohn, 1992)** and NWFP extraction in Ecuadorian Amazonia **(Jahinge *et al*, 1993)** also yielded similar results. Highly diverse NWFP were of great demand and most of them have annually renewable plant parts, which provide sustainable source of income.

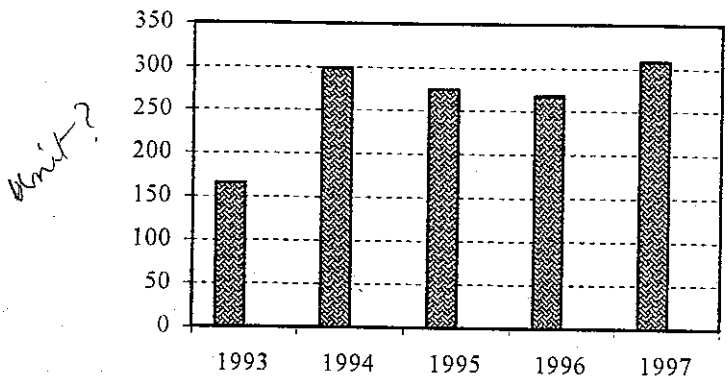
Sustainable extraction of these resources can provide tangible benefits to the local people simultaneously conserving the biological resources of standing forests, which in turn ensure other invaluable and infinite, indirect benefits of the forests.

NWFP has immense scope in the Indian forestry sector. Unfortunately, the potential of NWFP has been overlooked and underestimated. Seventy seven per cent of flowering plant families are represented in India which account for more than 21,000 species **(Tewari, 1991)**.

Study on the NWFPs of Kerala by **Thomas and Bai (1993)** shows that collection of NWFPs is a major component in the economy of tribal communities. Tribes (Girijans) account for 1.10% of the total population in the state **(Government of India, Census, 1991)**. They mainly depend on forest and agriculture for their livelihood. Till 1979, NWFPs were collected by contract system. The contractors, in turn employed the tribals to collect various products and provide meager wages as labour charge. In 1979, Kerala Government granted the exclusive right of collection of 120 notified items to the tribal through Girijan Service Co-operative Society (GSCS). Study also reveals that with less than 30% of GSCS functioning properly (out of the total 33 GSCS in the state) annual revenues of NWFP increased from 16.93 lakhs in 1982-83 to Rs. 38.42 lakhs in 1990-91. Contribution of NWFP as an income source to tribals varied from 12%-88% with a mean of 58% in the state **(Thomas and Bai, 1993)**.

The collection depots of Girijana Sahakarana Co-operative Society (GSCS) operating in the tribal hamlets in each administrative zone of the region were visited and data were collected on the products collected, its quantity and

Fig. 7. Quantity of NWFPs collected



procurement prices for the past 5 years. Forest dwellers in charge of collection and their hamlets were also visited and interviewed. The quantity of NWFPs collected from the study area during the past five years indicate that there has been a consistent flow of NWFPs from the forest (Fig. 7).

Mean quantity collected annually is estimated to be 269 tonnes ranging from a minimum quantity of 196 tonnes in the year 1993 to a maximum quantity of 307 tonnes in the year 1997 (Appendix 1). Mean quantity of products collected throughout the year during the past 5 years indicate that maximum quantity was collected in the month of January and minimum in the month of August. (Fig. 8; Appendix 2).

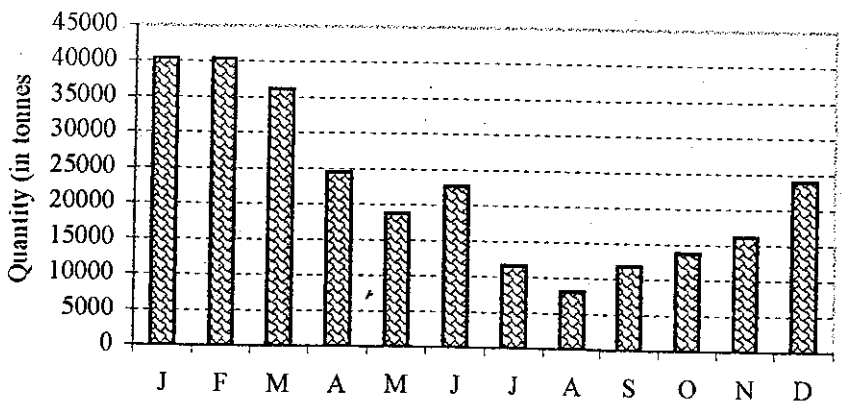


Fig. 8. Mean seasonal flow of NWFPs

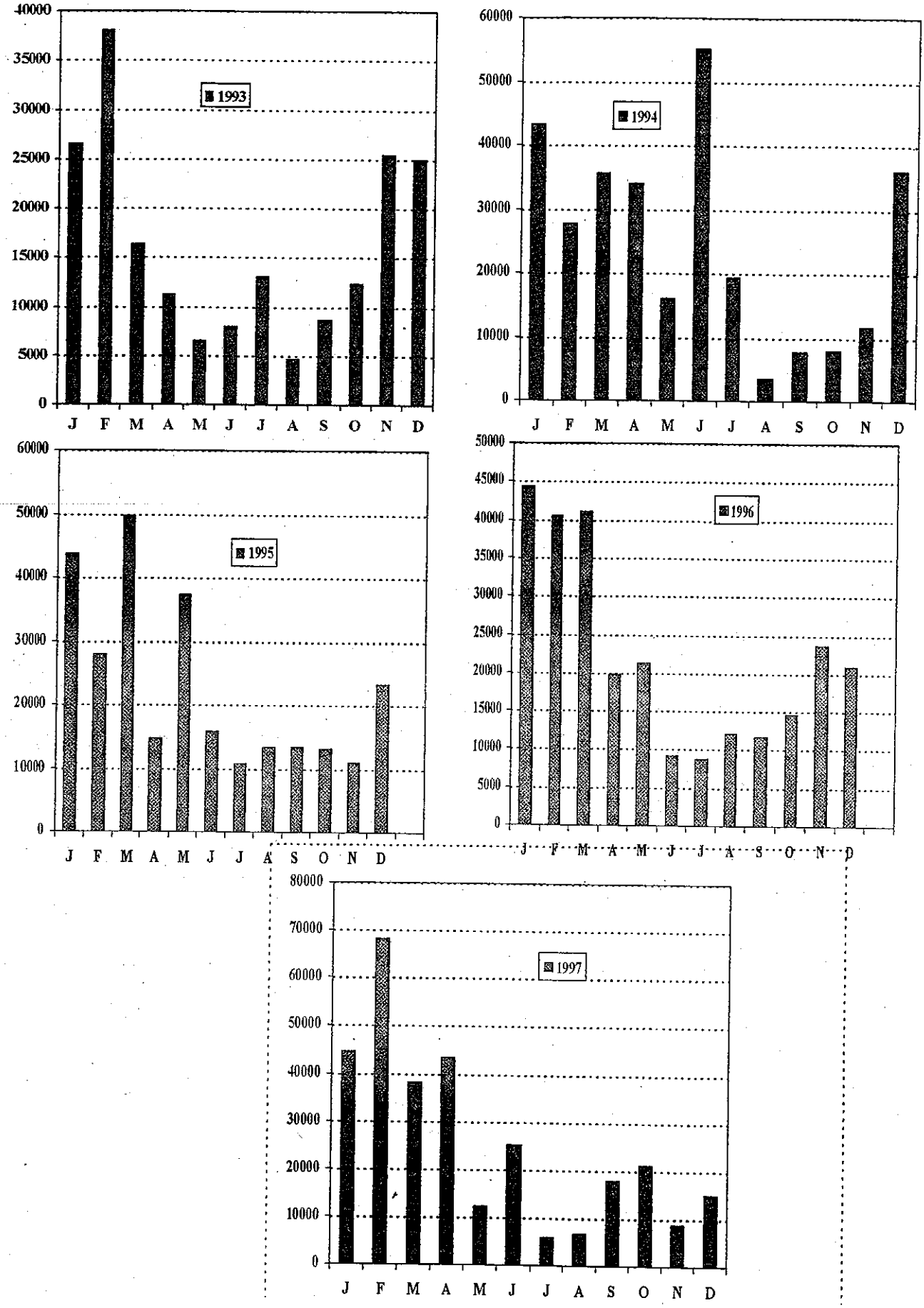


Fig. 9. Seasonal Flow of NWFPs (Kgs.)

The activity is seasonal with major outflow during November to February. Flow of products in the months during 1993-1997 is presented in Fig. 9.

The society in charge of collection of products from the forests, situated in the forest fringes are located at Nelliyampathy in Palakkad district, Palappilly and Sholayar in Thrissur district, Kuttampuzha in Ernakulam district, Adimaly, Devikulam, Kosady and Vazhathope in Idukki district. There are two more societies in the study area involved in collection of these products. These societies are either redundant or non enterprising collecting only few products during season with out any complete systematic accounting of products collected, functioning as only outlets for selling groceries and household items to the forest dwellers. These collection centers are often situated at remote localities with no access for motor

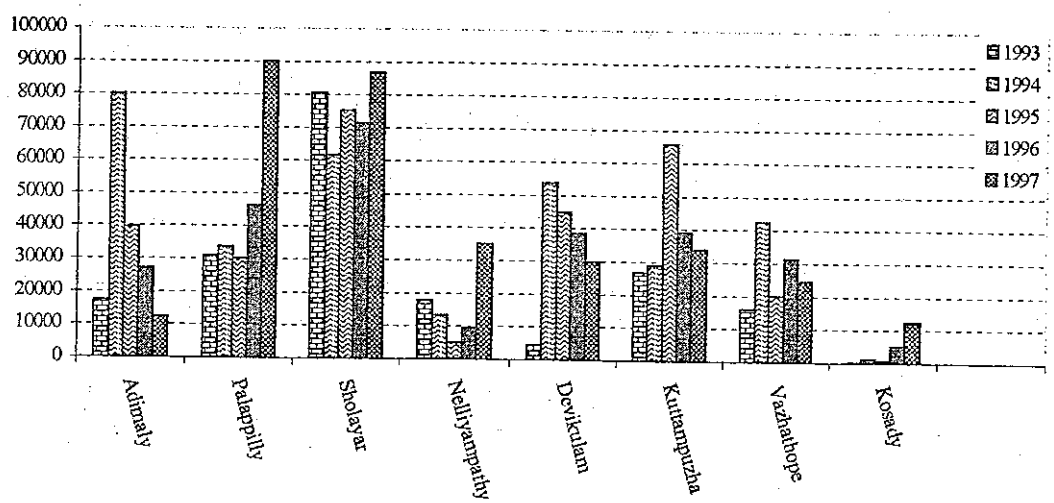


Fig. 10. Area wise extraction of NWFPs (Kgs.)

vehicles. Taking into consideration the non reliability of the information, data obtained from these two societies were excluded for data analysis.

A major share of the products were procured through the society located in Sholayar (Fig. 10). Collection of a variety of products ranging from a minimum of 61 tonnes to a maximum quantity of 86 tonnes per year collected 28% of the total products from the study area. Societies located at Palappilly procured an estimated annual average of 46 tonnes ranging from a minimum of 30 tonnes to a maximum quantity of 90 tonnes. Societies located at Kuttampuzha (39 tonnes), Adimaly (35 tonnes), Devikulam (34 tonnes), Vazhathope (27 tonnes), Nelliyampathy (16 tonnes) and Kosady (4 tonnes) were the other procurement centres listed in a descending order in terms of quantity of forest products collected (Appendix 3).

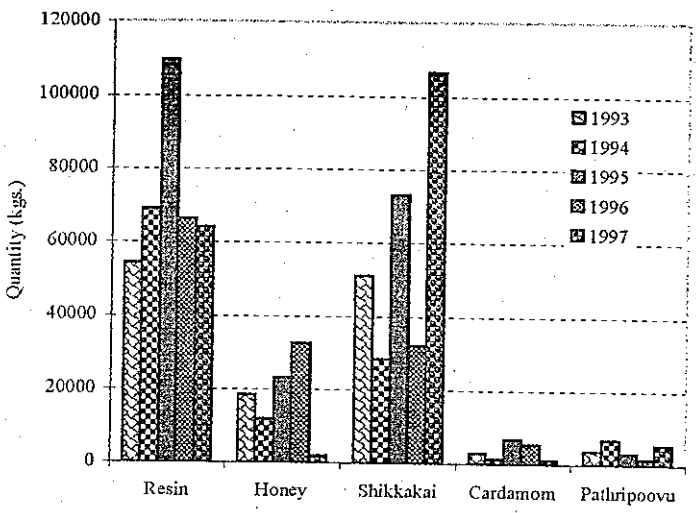


Fig. 11. Flow of selected NWFPs

Of the products collected from the study area, five products were selected in terms of its income generation potential. Resin, an exudate from the bark of tree *Canarium strictum*, Honey, Shikkakai, pods of the climber *Acacia simuata*, *Cardamom* and Pathripoovu are the selected five products. Quantity of resin collected from the study site during the year 1993 was 54.3 tonnes and showed an increasing trend in collection till the year 1995 and a declining trend thereafter (Fig. 11). Mean quantity collected annually was estimated to be 72.7 tonnes (Appendix 4). Extraction of honey increased from 1993 to 1996 and

decreased during the year 1997. Procurement of Shikakai was significantly high during the year 1995 and 1997, cardamom during the year 1995 and 1996, Pathripoovu during the year 1994 and 1997. (Fig. 11). Total quantity of items collected during the past five years and mean annual quantity collected are presented (Appendix 4).

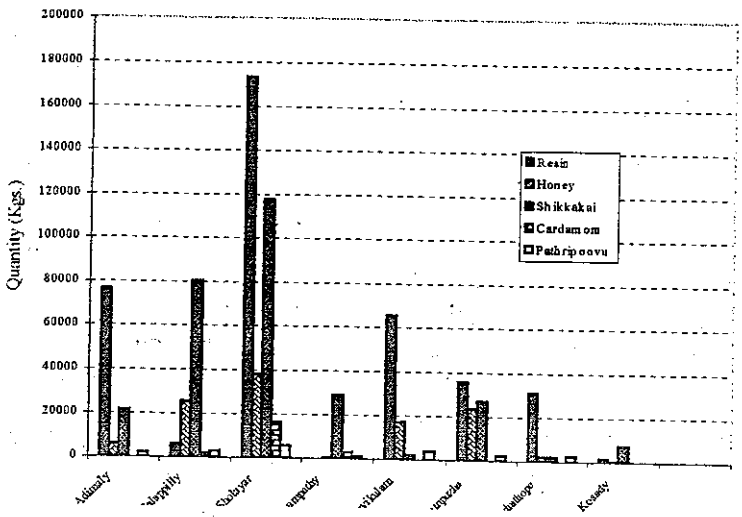


Fig. 12. Area wise extraction of selected NWFPs (Kgs.)

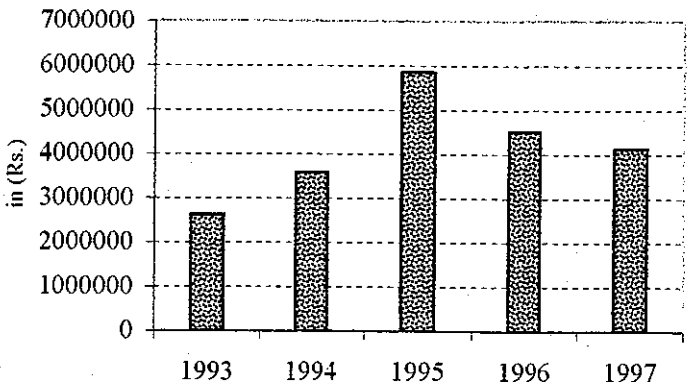
Major share of all the selected products were collected through the society located in Sholayar (Fig. 12). Quantity procured by other societies in the study area is given in Appendix 5.

1.2.2.1. Forest products as source of income generation

Besides fuelwood, fodder, green manure, poles etc. which are collected by the forest dwellers for household uses and for generating income through sales in the local market, there are other variety of plant and plant products which are used for industrial and medicinal purposes. Forest dwellers are largely dependent on these forest products as an income generating source. Moreover a wider network of industrialists, physicians, traders are dependent on the flow of these resources from the forest collected by the forest dwellers. Most of these products are ingredients in various important ayurvedic medicinal combinations which are

popular and widely consumed. It is estimated that forest products worth over 4.14 million rupees (Mean annual income) is annually extracted from the study area (Appendix 6). This estimate is based on the accounts compiled from the societies

Fig. 13. Income generated through NWFP collection



operating in the study area. Products sold through bye passing these societies directly to the traders, or mismanagement and incomplete documentation are hurdles in estimating the actual flow. Income generated through collection of forest products showed an increasing trend from 1993 to 1995 and a decreasing trend thereafter (Fig. 13).

Mean seasonal income generated indicate highest income accrued during the month of March and lowest during the month of July (Fig. 14).

Income generated during the past 5 years and average income accrued in each month are presented in Fig. 15 and Appendix 7.

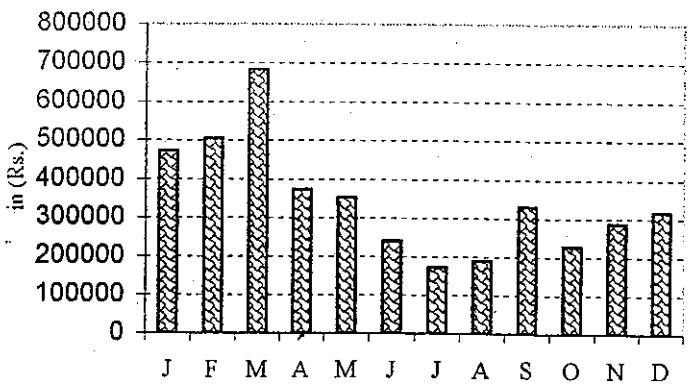


Fig. 14. Mean seasonal income accured through NWFP collection

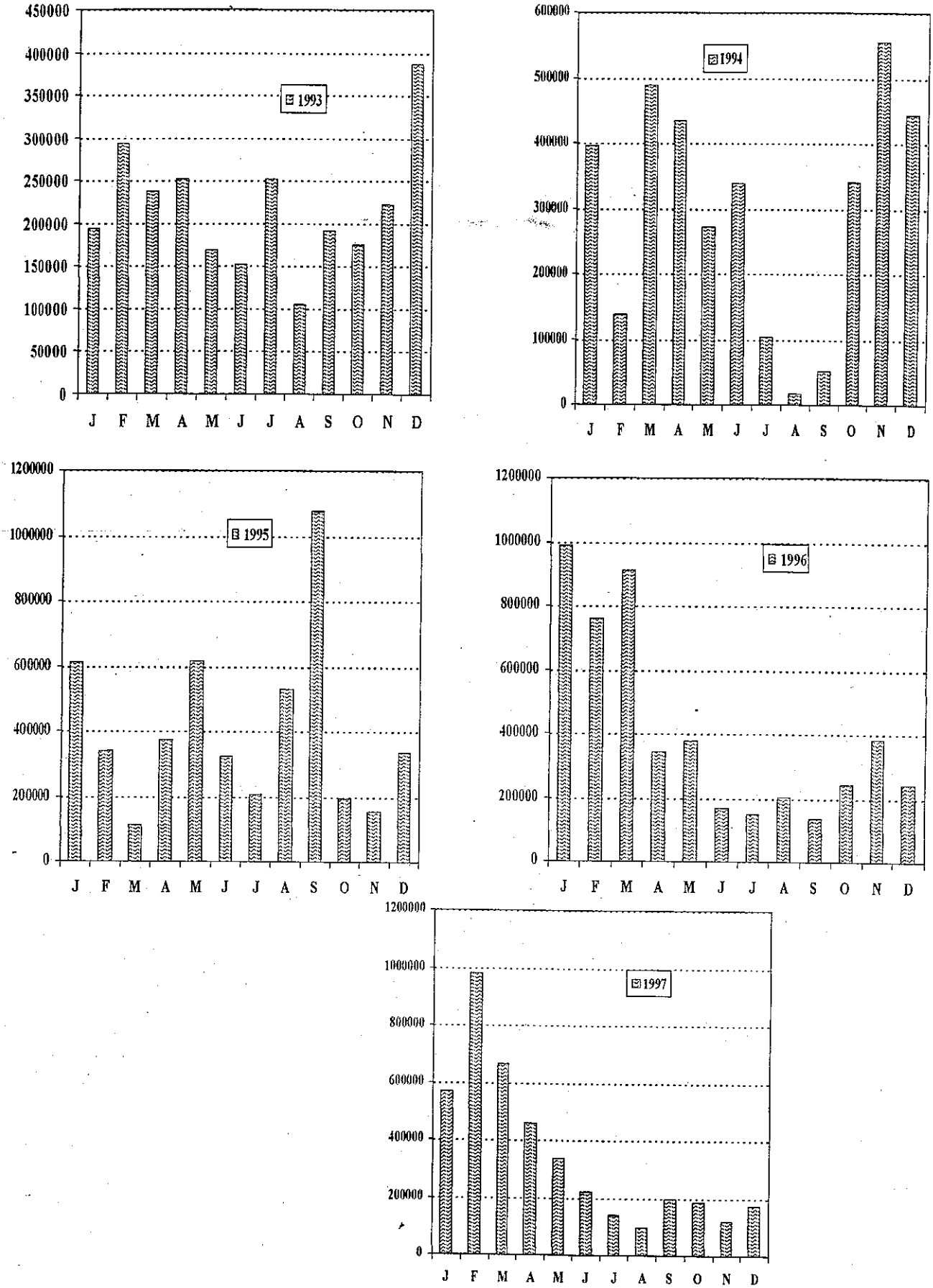


Fig. 15.Seasonal fluctuation in income generated through extraction of NWFPs (Rs.)

Income generated through selected NWFPs are presented in Appendix 8. Resin was found to be the single item which contributed majority of the income. Mean annual income accrued is estimated to be 1.114 millions rupees. Honey is the second largest individual product in contributing income. Mean annual income is estimated to be 0.834 million rupees followed by Shikkakai (0.39 million rupees), Cardamom (0.368 million rupees) and Pathripoovu (0.218 million rupees). The fluctuation in income accrued through these selected products during the past five years is shown in Fig 16.

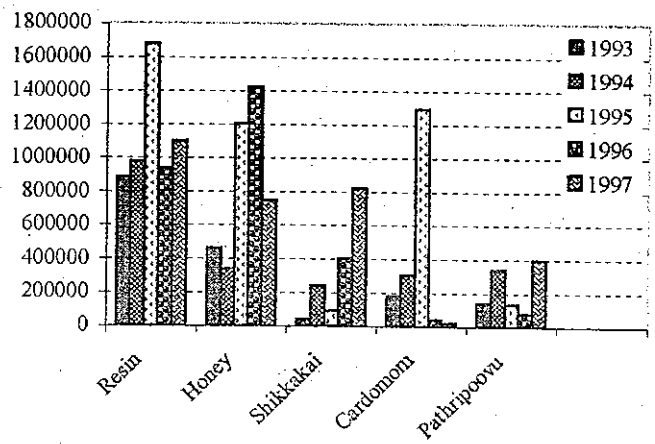


Fig. 16. Income generated through extraction of selected NWFPs (Rs.)

Forest dwellers at Sholayar received the highest returns through selling the products. Mean annual average is estimated to be 1.4 million rupees (Appendix 9). Annual fluctuation in income is shown in Fig. 17. The other successful foragers of forest products were from Palappilly (0.6 million rupees), Kuttampuzha (0.57 million rupees) and Devikulam (0.56 million rupees).

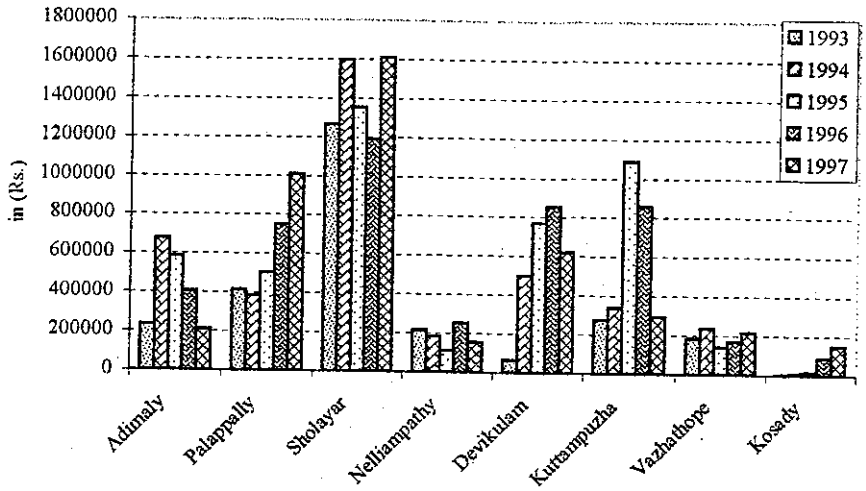


Fig. 17. Income generated areawise through NWFPs extraction

Selected NWFPs also showed a similar trend. Highest turn over through collection and sales is recorded in society located at Sholayar. Collection and sales of resin is the major source of income for the people living in Sholayar, Adimali, Devikulam and Kuttampuzha. (Fig. 18, Appendix 10). Collection and sales of Shikakai is the major source of income for people at Nelliyampathy and Kosady.

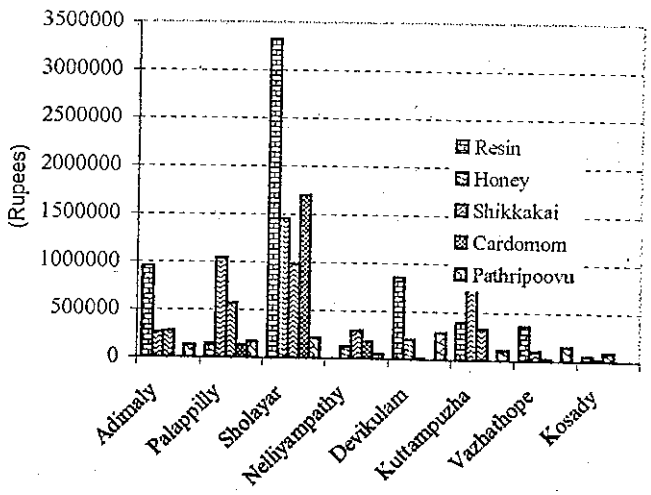


Fig. 18. Income generated area wise through extraction of selected NWFPs (Rs.)

Price fluctuation of selected products during the past 5 years is shown in Fig. 19. Procurement cost per kilogram in rupees for these products during the past 5 years is taken and analyzed (Appendix 11). An exhaustive list of the products, its quantity and income accrued is given in Appendix 12.

The procurement price of resin gradually declined during 1993-1996 and showed an inclining trend thereafter. Price of honey indicated a steep increase during 1995 and later showed a declining trend. Price of Shikkakai gradually increased during the years 1993-1996 with a sharp decline in 1997. The trend in

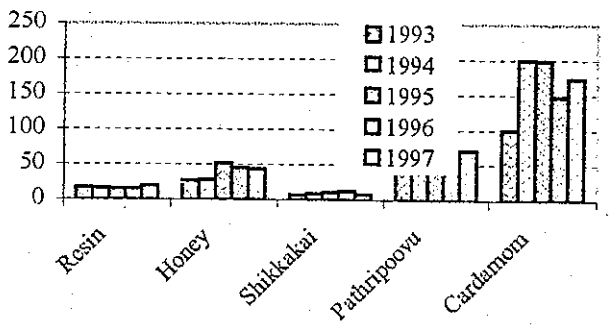


Fig. 19. Fluctuation in prices of selected NWFPs (Rs. Kg.)

the case of Pathripoovu was found to be promising with an overall hike in prices. The price of cardamom almost doubled in the year 1994 and later showed a declining trend.

1.3 Biodiversity

1.3.1. Floristic diversity

The Southern Western Ghats is considered to be the hottest of hot spots of floristic diversity and endemism in India with largest number of endemic species in India. The Southern Western Ghats in Kerala has a flora of 10035 species which represent 22 percent of Indian flora occupying a land mass of 1.18 percent of India. There are 3800 species of flowering plants of which 1272 (33 per cent) are endemics (Nayar, 1997). There are 460 species which fall under the rare/threatened/vulnerable and endangered categories comprising 12 percent. An account on the plant species diversity in the Southern Western Ghats of Kerala is given in Table 8.

Table 8. The plant species diversity in Kerala

Taxa	No. of species
Angiosperms	3800
Gymnosperms	4
Pteridophytes	236
Bryophytes (Moss)	350
Lichens	520
Algae	325
Fungi	4800
Total	**10035**

Source: Nayar, M.P, 1997. Biodiversity challenges in Kerala and Science of Conservation Biology in (eds.) Pushpangadan, P and Nair, KSS. Biodiversity and tropical forests STEC. pp-9

The study region has 3049 angiosperms (80.24 percent of the angiosperms in the State) of which 1015 are endemics which accounts to 33.29 percent. There are 203 rare, threatened, vulnerable and endangered species which accounts for 44.13 percent of the species of this category in the state is available in the region. 80 percent of the endemic species of the State is also being represented from the region. Region harbour a significant portion of the floristic diversity of the state and hence assumes great importance in the context of biodiversity. To identify the floristically richest areas in the study region secondary data on floristic inventory

of each area were compiled. Most recent publications were used for the purpose. Criteria for selection of the most important floristically rich areas are as follows:

1. Number of angiosperms identified from the area
2. Number of plant species which are exclusively found in the area
3. Number of species of endemic, rare and threatened categories

Table 9. Floristic diversity in the region

Sl. No	Area	Angio-sperms	Exclu-sive species	%	End-emic	%	Rare/ Threa-tened/ vulnerable/ endangered	%	Source
1.	Kerala	3800	--	--	1272	33.47	460	12.1	Navar, 1999
2.	GKR	3049	--	--	1015	33.29	203	7.3	Compiled
3.	Periyar Tiger Reserve (PTR)	1965	777	39.54	515	26.20	150	7.6	Sasidharan, 1998
4.	Pathanamthitta	1250	202	16.18	253	20.24	175	14	Anil kumar, 1993
5.	Thrissur	1200	162	13.5	258	21.5	51	4.3	Sasidharan, 1994
6.	Eravikulam	274	138	50.36	62	22.63	29	10.6	Karunakaran, 1997
7.	Kottayam	885	211	23.84	--	--	--	--	Antony, 1989

The contiguous patch of evergreen forests in and around PTR is identified as the floristically richest area of the study region (Table 9). The forest patches of Periyar Tiger Reserve harbour 1965 angiosperms from 151 families representing 695 genera with 515 endemic plant species of which 150 belong to the rare and threatened categories (Sasidharan, 1998). 777 plant species are exclusively found in this region which are not recorded from other areas in the region. According to Sasidharan presence of 168 species of grasses and bamboos in PTR is the richest assemblage in any protected area or in any other part of the State. Occurrence of 155 species of Luguminosae and 143 orchids including a new species *Habenaira periyarensis* (Sasidharan *et al.*, 1988) and an endangered one *Taeniophyllum scaberulum* (rediscovered after 140 years) are the highest number recorded from any protected area in the Western Ghats.

1250 angiosperms were recorded from Pathanamthitta. 148 families represented 658 genera with 253 endemics, of which 175 were under rare and threatened category (Anil kumar, 1993). 202 plant species were exclusively found in this area, which were not recorded from other areas in the region. This area

assumes high importance recording 14 percent of the rare and threatened categories which is highest in the region.

Of the 1200 angiosperms recorded from Thrissur 258 were endemics constituting 21.5 percent and 51 under rare and threatened category forming 4.3 percent of the total (Sasidharan, 1994). There are 162 exclusive species constituting 13.5 percent. 274 species were recorded from Eravikulam of which 62 were endemic constituting 23 percent and 29 under rare and threatened category comprising 10.58 percent (Karunakaran, 1997). 50.36 percent of the species found here were represented only from this area in the region which is highest in the study region and assumes great importance for the conservation of this unique habitat. Of the 885 species recorded from Kottayam (Antony, 1989) 211 (24 percent) were exclusively found in this area.

1.3.2. Faunistic diversity

Table 10. Faunistic diversity of the State

Group	No. of genera	No. of species	No. of species world total *
Vertebrates (Animals with backbone)			
Pisces (Fishes)		196	19,056
Amphibia (Aamphibians)		86	4,184
Reptilia (Reptiles)		142	6,300
Aves (Birds)		475	9,040
Mammalia (Mammals)		75	4,000
Invertebrates[b] (Animals without backbone)			
Protozoa	63	--	30,800
Porifera (Sponges)	22	--	5,000
Coelenterata (Jelly fish, corals)	90	--	9,000
Platyhelminthes (Flatworms)	117	--	12,200
Acanthocephala	16	27	--
Aschelminthes	265	121	--
Annelida (earth worms, leaches)	46	91	12,000
Chaetognatha	4	18	--
Mollusca (snails, oysters, etc)	19	26	50,000
Echinodermata (starfish, sea cucumbers)	7	8	6,100
Insecta (insects)[c]	193	6000	751,000
Non-insect Arthropoda (Crustaceans, mites, spiders)	242	--	123,161

Source: [a] Wheeler (1990); [b] Radharishnan, ZSI (Pers. Comm.); [c] George Mathew, KFRI (Pers. Comm.), Compiled by: KSS, Nair and PS, Easa. 1997. Animal Biodiversity in Kerala Forests. In. (Eds.) Pushpangadan, P. Nair, KSS. Biodiversity and Tropical Forests. The Kerala Scenario. The State Committee on Science, Technology and Environment (STEC), Kerala pp. 88.

An account of the faunistic diversity of the State is given in table 10. With which more invertebrates, and vertebrates to be compiled and to be explored in the natural habitat, this list is an underestimate. (Nair and Easa, 1997). Of this, larger mammals and birds have been comparatively better studied. Of the 40 mammals which are endemic to India, 15 species are from the Western Ghats. (Nameer, 1998).

The study region is rich in faunal diversity. The Wildlife census conducted by KFRI in 1993 (Table 11) provides evidence to the same. Nearly 42 percent of the most endangered primate Lion Tailed Macaque (LTM), 80 percent of Nilgiri Langur (endemic to Western Ghats) and 35 percent of bonnet macaques of the State are found in the region. The density of mouse deer (an endangered species) Wild boar, toddy cat etc are also well represented. Many areas abode good habitat to support large population of Small Indian civet, sambar, gaur, elephant etc. Periyar Tiger Reserve and its adjoining forests support a good number of leopards and tigers. Highly endangered Rusty spotted cat was recently reported to be present (Nair and Easa, 1997).

Of the 475 species of birds reports from the State of which 10 are endemic to Western Ghats 249 species are present in PTR, 185 in Parambikulam, 177 in Peechi and 160 in Chimmoni adjacent to Thrissur were also reported (Nair and Easa, 1997). The rare forest cane turtle recently rediscovered from Chalakudy forests, and the starred tortoise in the semi-arid tracts of Chinnar (Nair and Easa, 1997) highlights the importance of biodiversity conservation the region.

Table 11. Population density of larger mammals in the region

	*Lion tailed macaque	*Bonnet Macaque	*Nilgiri Langur	*Common langur	*Elephant	**Gaur	**Sambar	**Spotted deer	**Barking deer	**Mouse deer	**Wild boar	**Sloth Bear	**Wild dog	**Porcupine	**Small Indian civet	**Toddy cat
Kerala	960	4800	2987	--	2388	410.49	1226.84	427.44	5589.85	259.02	577.50	223.54	148.42	250.95	195.58	126.95
GKR	405	1717	2384	--	1815	38956	1097.86	384.6	641	233.06	579.91	148.59	159.62	272.74	146.68	119.9
Nenmara	45	64	13	--	26	30.54	175.00	19.23	140.49	40.86	174.16	178.91	65.82	19.23	19.23	--
Parambikulam	45	54	105	--	30	1861.08	1406.25	239.60	250.00	72.42	250.00	310.28	62.50	108.14	159.73	--
Thrissur	--	54	-	--	--	41.67	2402.42	631.83	437.50	208.30	278.12	438.54	143.75	1061.67	781.00	--
Chalakkudy	15	122	19	--	9	18.39	535.70	--	246.45	31.25	360.70	--	357.10	258.05	--	--
Vazhachal	90	270	256	--	142	528.80	291.38	125.00	3887.33	218.75	184.03	--	364.60	86.80	52.08	125.00
Malayattoor	30	148	10	--	131	6.54	2016.25	--	500.00	343.07	623.60	20.83	187.50	117.10	166.70	156.25
Kothamanagalam	--	82	--	--	42	--	950.00	--	324.45	351.10	449.05	110.80	--	67.70	28.09	42.13
Mankulam	--	20	--	--	--	1652.78	825.94	--	500.00	150.00	395.28	155.46	142.71	101.86	41.67	200.00
Munnar	15	248	164	--	156	159.69	125.00	28.91	506.92	250.01	--	--	--	83.33	--	34.08
Idukki (WL)	--	155	99	20	96	406.30	1290.50	1916.00	444.99	500.00	615.40	33.00	313.89	891.33	241.26	69.97
Kottayam	15	78	--	--	25	3.25	1387.00	28.85	461.10	259.60	256.00	19.23	35.41	152.45	28.85	68.52
Periyar Tiger Reserve	90	48	1530	--	615	333.18	1356.83	--	248.55	200.00	282.35	284.68	216.60	417.05	84.29	218.10
Ranni	60	269	188	--	433	12.60	1791.33	--	722.73	554.23	3404.27	63.29	215.30	404.75	10.55	232.44
Konni	--	105	--	--	110	9.54	816.20	87.91	304.60	83.36	265.90	19.08	147.62	48.85	--	52.39

1.4. Forest Dwellers in the region

There are 38000 forest dwellers in the region according to the tribal survey conducted by the Kerala Forest Department (1992). Females constitutes 49.67 percent. Among the twenty different tribes in the region, prominent group are Muthuvas, Ooralies, Hill Pulayas, Mannans, Malayarayas and Ulladans. 45.82 percent of the population are dependent on forest resources for their livelihood. 22.96 percent of the population is employed as wage labourers.

Income accrued through various activities is listed in table 12. Agricultural activities inside the forests, collection of Non Wood Forest Produce (NWFPs) hunting, fishing, cottage industries and household works are categorised as forest dependent activities. Income obtained through forestry related works, often as wage obtained through forestry related works as wage labourers is taken into account.

Higher altitudes of the high ranges are predominantly occupied by the Muthuvas. They practice shifting cultivation, substantiating their income through collection and marketing of Non Wood Forest Produce (NWFPs). Tribal settlements at Idamalakudy in the Idamala-Pooyamkutty basin has significant high number of Muthuvas as residents. Shifting cultivation and cardamom cultivation are the major income generating activities. Land holding of individual households under cardamom ranges from 5-70 acres. Drastic decline in cardamom prices has affected households in the region. This has persuaded them to collect other NWFPs from the surrounding forests to meet subsistence needs. This cluster of remote settlements has a collection depot of GSCS to collect the forest products exchanging rice and other grocery items. Decreasing market prices for the forest products and increasing prices for all grocery items has been the trend for the past few years. This widening gap between the market prices could probably build enormous pressure on the surrounding forests in the years to come.

Other pockets of settlements of Muthuvans are in the upper reaches of Anamalais, Chinnar Wildlife Sanctuary and Sholayar. Dispersed settlements in and around Sholayar namely Chinnapparakudi, Thumbiparakudy, Malakkapara, Adichitithotty, Andavarkudy, Pudukudy etc substantiate higher proportion of their income through collection and sales of Non Wood Forest Produce (NWFPs).

Table 12. Division wise distribution of tribal population according to type of main employment

Division	Male	Female	Total	A	B	C	D	E	F	G	H	I	J	I	J	L	M
Parambikulam	415	433	848	290	0	0	3	76	109	142	16	0	79	63	16	0	54
Nenmara	432	400	832	832	72	0	0	43	45	187	4	3	140	12	1	29	27
Chalakkudy	750	766	1516	1516	223	1	10	233	400	234	25	41	137	24	9	1	97
Vazhachal	507	506	1013	1013	199	0	1	27	83	158	34	14	204	2	5	3	87
Malayatoor	942	857	1799	1799	26	0	4	365	33	705	75	5	0	0	3	0	60
Kothamangalam	3349	3309	6658	6658	1	0	4	1564	1710	270	367	418	3	4	160	3	50
Munnar	4645	4520	9165	9165	103	7	10	1923	1359	2122	380	1555	76	4	36	5	215
Kottayam	4265	4249	8514	8514	10	5	14	1650	1942	472	486	1224	487	11	225	1	598
Idukky	1421	1440	2861	2861	2	1	0	453	429	143	298	114	24	0	9	0	726
Ranny	2148	2169	4317	4317	33	2	18	1097	842	627	176	860	105	40	56	10	124
Konni	137	113	250	250	93	0	0	30	4	30	37	0	8	0	0	2	8
Achencoil	114	113	227	227	1	0	0	59	46	35	0	19	14	35	0	1	3
Total	19125	18875	38000	7152	763	16	64	7520	7002	5125	1898	4253	1277	306	520	55	2049

Forest Department activities

A – Farming
B – Collection of NWFPs
C – Hunting and fishing
D – Cottage industries
E – Household work
F – Student
G – Unemployed
H – Others

Wage labourers

I – Agricultural labourer
J – Forest plantation labourer
K – Tree cutting, loading work
L – Government work
M –Collection of NWFPs (labourer)
N – Others

Source: Tribal survey conducted by Kerala Forest Department (1992)

2. ASSIMILATIVE CAPACITY

Heavy monsoon showers in Kerala support a luxuriant vegetation growth. Homesteads in Kerala abode rich assemblage of tree species. Potential of vegetation in the homesteads in assimilating the pollutants around critically polluted regions were targeted.

The Eloor industrial belt is recognised as a critically polluted area in the study region. There are seven large industrial units which are the major polluting industries. Details on the emission of sulphur dioxide (kg/day) is given in table 13.

Table 13. Baseline salient features of industrial stacks

Name of industry	So_2 discharge Q Kg/Day	Stack height M	Stack diameter at exit m	Stack velocity at m/sec	Temp OC at exit
1	2	3	4	5	6
Source I					
Travancore	1987.20	15.00	1.10	3.00	250
Cochin	3974.40	25.00	1.20	2.50	300
Chemicals	1987.20	24.60	0.40	9.00	200
Hindustan Organic	321.50	39.00	1.45	6.50	130
Chemicals	321.50	51.00	1.85	11.50	275
FACT	9936.00	75.00	2.50	1.00	65
(Udyog Mandal)	13478.40	25.00	1.22	1.07	200
	5529.60	16.60	1.22	1.07	200
Hindustan Insecticides	5616.00	12.17	0.78	3.50	180
Indian Rare Earths	816.48	18.00	0.77	3.13	132
Cominco Binani Zinc Ltd.	201517.00	40.00	0.80	3.85	400
ASCL	1656.28	90.00	3.35	5.54	150
Caprolactam	47.52	30.00	0.36	8.64	343
Source II					
FACT	14005.00	65.00	1.80	8.60	65
(Ambalamughal)	2634.00	105.00	--	8.58	185
	1945.80	39.00	2.75	16.89	45
	4980.40	33.40	1.85	11.35	55
Carbon and chemicals	2901.00	40.00	2.70	12.00	450
Cochin refineries	802.00	45.00	1.25	7.13	300
	1776.60	60.00	1.55	6.42	235
	395.08	21.00	1.44	9.67	240
	446.69	32.00	2.21	8.17	272
	583.74	80.00	--	--	--

Studies on the isolines of So_2 concentration (Bindu, Ph.D thesis unpublished) reveal that the most affected regions are Eloor, Varapuzha, Cheranelloor and its environs. Green peace investigation report also has identified this region as the toxic hot spot.

2.1. Homesteads as sink for pollutants

Homesteads in and around the Eloor, Varapuzha and Cheranelloor regions around the industrial belt was surveyed to identify the composition of trees in the homesteads and to find out the density of trees in the vicinity.

168 households were surveyed in the three Panchayat regions. Trees grown in the homesteads, its density and diversity were studied. Total area of land under homesteads surveyed was 42.63 acres of which 25 acres were from Eloor of 81 households, 6.09 acres from Cheranelloor of 27 homesteads and 11.45 acres from Varapuzha of 60 households. A total number of 58 species were recorded from the region of which 44 represented from Eloor. Average size of land holding was 0.25 acres per household with an average of 141 trees per acre. Tree density is high in Varapuzha from a mean landholding of 0.19 acres/household followed by Eloor with 135 trees per acre from a mean land holding of 0.31 (acre/household) (Table 14).

Table 14. Details of homesteads around the Eloor Industrial Complex

	Total number of homesteads surveyed	Total area surveyed (acres)	Total number of tree species	Average size of land holding (acres)	Number of individuals/ acre
Eloor	81	25.09	44	0.31	135
Cheranellur	27	6.09	33	0.23	100
Varapuzha	60	11.45	25	0.19	188
Total	**168**	**42.63**	**58**	**0.25**	**144**

In the homesteads of Eloor and Varapuzha arecanut is most dominant, followed by coconut. Among the 58 species found in the homesteads coconut,

arecanut, plantains, mango and jack were the common assemblages. Density of these species is given in Table 15.

Table 15. Density of the most dominant tree species in the homesteads

Tree Species	Density (Individuals/Acre)		
	Eloor	Cheranellur	Varapuzha
Arecanut	39	15	59
Coconut	37	35	47
Plantain	35	16	30
Mango	8	11	8
Jack	4	4	9
Others	11	19	36

2.2. Sink potential of species in the homesteads

The most dominant plant species in the homesteads were identified and its density was estimated. Leaf samples were collected from the dominant trees of the homesteads and were taken to the laboratory to estimate the stomatal density. Stomatal density per mm^2 of the leaf is given in table 16.

Table 16. Stomatal density/mm^2, leaf of dominant species in the homesteads

Species	Control	Polluted
Arecanut	214	182
Coconut	172	143
Plantain	168	179
Mango	626	--
Jack	299	360

Stomatal density per mm^2 of the leaf on lower epidermis for each species collected from the study site and from a control (KFRI campus) was compared. For arecanut and coconut stomatal density were lower in the polluted sites and for plantain and jack the stomatal density was higher (Table 16). The stomatal count of mango at the polluted site could not be estimated due to the failure of the laboratory technique adopted. Among the dominant trees of the homesteads, mango and jack could be an effective potential sink for pollutants. Certain tree

species has been recommended for greenbelt with reference to its sink potential based on stomatal density.

Certain plant species with respect to its stomatal density in the leaf is listed in table 17. Tree species with highest stomatal density among the selected species were *Castanospermum australe*, an exotic tree and *Mangifera indica*. Twenty tree species which could be recommended for green belt with reference to its sink potential is given in Table 17.

Table 17. Assimilative capacity of plants – plants recommended for green belt with reference to its sink potential

Sl. No.	Name of the species	Stomatal density (mm^2) of leaf area in the lower epidermis
1.	*Castanospermum australe*	698
2.	*Mangifera indica*	626
3.	*Eucalyptus pilularis*	523
4.	*Eucalyptus deglupta*	495
5.	*Tectona grandis*	416
6.	*Gliricidia sepium*	389
7.	*Anacardium occidentale*	383
8.	*Eucalyptus urophylla*	365
9.	*Xylia xylocarpa*	360
10.	*Acacia auriculiformis*	359
11.	*Michelia champa*	307
12.	*Acacia mangium*	293
13.	*Artocarpus heterophyllus*	275
14.	*Swietenia mahogoni*	263
15.	*Elais guineensis*	248
16.	*Annona squamosa*	227
17.	*Syzygium cumini*	215
18.	*Areca catechu*	214
19.	*Pongamia glabra*	209
20.	*Ficus benghalensis*	200

2.3. Response of residents on the quality of life

Preliminary surveys were conducted to study the impact of pollution in these areas. A questionnaire based survey is conducted to collect the response of the residents from 168 households and were analyzed. Eloor was found to be the most affected region. 89 per cent of the households in Eloor and Cheranellur area opined that their lives are seriously affected and air quality is deteriorating.

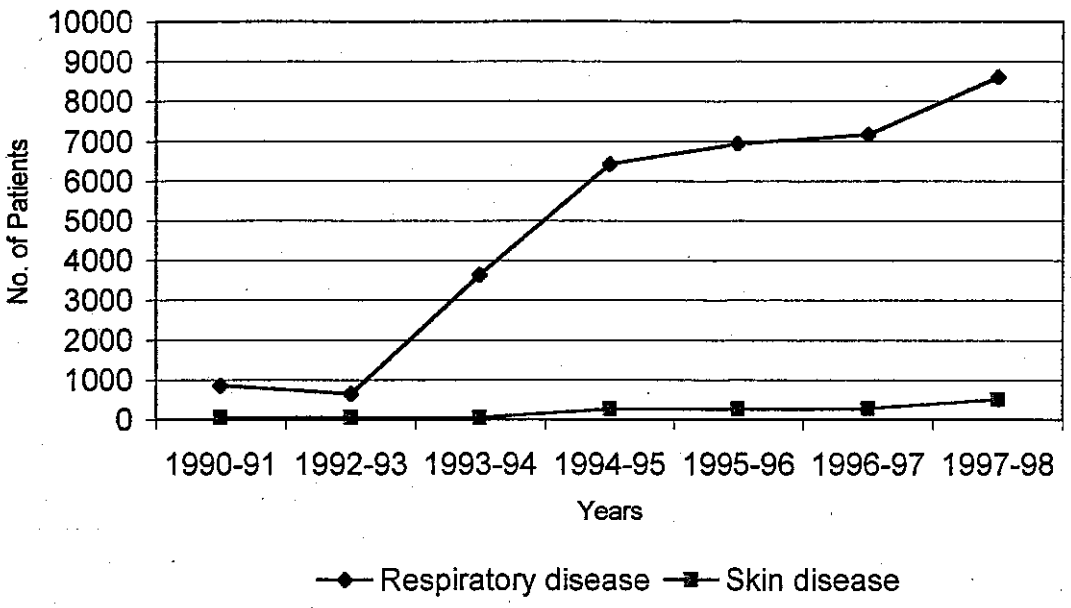


Fig. 20. **Increasing incidence of respiratory and skin diseases among residents at Varapuzha**

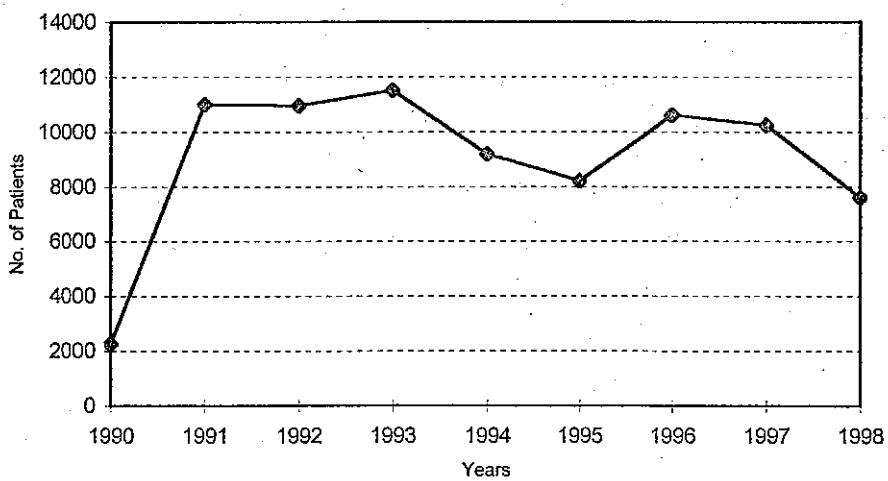


Fig. 21. **Increasing incidence of respiratory ailments among residents around Elur**

Source: Primary Health Centres (Varapuzha and Binanipuram)

Incidence of diseases is also high in Eloor. Details are presented in Table 18. To substantiate this finding the doctors at the Primary Health Centres (PHC) were interviewed and the medical registers were also referred to. Data collected from the primary health centre of Varapuzha and Binanipuram are given in figure 20 and 21. Increasing incidences of respiratory and skin diseases were evident among the residents. Decrease in number of patients during the last year as per the records of PHC at Binanipuram could be due to the fact that the condition of the patients in Eloor is often worse that they often go to hospitals at Cochin.

Table 18. Response of the residents in and around the Industrial Complex at Eloor (Households in percentage)

	Eloor	Cheranellur	Varapuzha
Pollution is seriously affecting their lives	89	89	87
Affected with diseases related to pollution	81	56	67
Well water is affected	54	70	57
Agricultural crops are affected	42	56	45
Live stock is affected	88	0	27
Agricultural productivity has declined during the past few years	42	56	45
Deterioration of air quality during the past few years	89	89	87
Deterioration of water quality during the past years	54	70	57

2.4. Characteristics of the substratum of municipal waste dumping, site

The characteristics of the substratum of municipal waste dumping sites in the study region are given in Table 19. Municipalities which has a permanent waste dumping yard is visited and 5 soil samples are collected from one meter pits at an interval of 20 cms. Sites at Alapuzha, Chertala, Kayamkulam and Paravur have sandy substratum with over 90% of sand and with 5 per cent clay or even in less quantities. Substratum of sites at Changanasseri, Kothamangalam, Pala and Kodungalloor composed of 80-90% of sand, of which gravel content was more in the samples from Changanasseri. Substratum composed of 70-80 per cent of sand is observed at Thodupuzha, Chenganoor, Kottayam, Iringalakuda, Aluva, Moovattupuzha and Chenganoor. Of which the last four sites had high gravel content. Per cent of clay is high in samples from Kottayam.

Table19. Characteristics of the substratum of Municipal waste dumping sites

Sl. No.	Sample	Gra-vel %	pH	O.C %	Sand %	Silt %	Clay %	WHC %	PS %
Alapuzha									
1.	0-20	3	6.0	0.11	96	0	4	27	37
2.	20-40	0	5.5	0.06	96	0	4	23	37
3.	40-60	0.3	6.1	0.06	96	0	4	24	37
4.	60-80	0	6.3	0.06	95	0	5	19	37
5.	80-100	0.2	6.2	0.06	96	0	4	24	37
Aluva									
6.	0-20	41	4.8	0.90	73	10	17	51	40
7.	20-40	51	5.1	0.56	77	16	7	39	42
8.	40-60	48	5.0	0.73	77	9	14	45	42
9.	60-80	50	4.8	1.09	72	9	19	52	40
10.	80–100	53	5.0	0.79	76	17	7	50	45
Changanassery									
11.	0-20	58	5.4	1.44	87	5	8	48	42
12.	20-40	50	5.3	0.25	84	6	10	40	37
13.	40-60	35	5.4	0.17	86	5	9	40	48
14.	60-80	52	5.3	0.17	85	5	10	36	48
Chengannoor									
15.	0-20	21	4.8	1.50	71	12	17	41	47
Cherthala									
16.	0-20	0.3	5.1	0.14	95	1	4	27	37
17.	20-40	0	5.0	0.06	96	0	4	24	37
18.	40-60	0.3	5.2	0.08	95	0	5	20	34
19.	60-80	0	4.9	0.06	96	0	4	24	35
20.	80-100	0	5.4	0.06	96	1	3	24	36
Irinjalakuda									
21.	0-20	52	4.3	1.71	73	12	15	48	42
22.	20-40	49	4.2	1.35	75	9	16	48	39
23.	40-60	48	4.5	0.87	76	8	16	45	36
24.	60-80	48	4.7	0.76	74	7	19	46	35
25.	80-100	58	4.8	0.79	74	6	20	44	30
Kayamkulam									
26.	0-20	4	5.9	0.37	91	4	5	33	41
27.	20-40	16	7.3	0.40	91	4	5	37	42
28.	40-60	14	7.1	0.08	92	2	6	31	39
29.	60-80	14	6.9	0.06	92	1	7	32	51
Kodungaloor									
30.	0-20	26	4.6	1.66	86	6	8	40	36
31.	20-40	29	4.8	0.31	80	6	14	34	27
32.	40-60	36	4.8	0.42	74	7	19	34	44

WHC = Water Holding Capacity; PS = Porosity

Table 19. Characteristics of the substratum of Municipal waste dumping sites (Contd..)

Sl. No.	Sample	Gra-vel %	pH	O.C %	Sand %	Silt %	Clay %	WHC %	PS %
Kothamangalam									
33.	0-20	21	5.6	1.59	87	7	6	49	43
34.	20-40	028	5.6	1.10	88	7	5	50	45
35.	40-60	17	7.1	1.13	83	10	7	42	39
36.	60-80	17	5.7	0.91	82	12	6	47	42
37.	80-100	18	5.7	0.31	87	8	5	42	41
Kottayam									
38.	0-20	42	4.5	1.56	82	6	12	50	28
39.	20-40	45	4.4	1.10	85	7	8	48	51
40.	40-60	18	4.7	0.88	78	7	15	50	44
41.	60-80	46	4.9	0.08	74	6	20	42	43
42.	80-100	42	5.4	0.91	76	6	18	41	45
Moovattupuzha									
43.	0-20	41	5.1	0.82	77	12	11	41	48
44.	20-40	51	5.4	0.59	78	12	10	42	44
45.	40-60	55	5.3	0.45	78	12	10	40	42
46.	60-80	72	5.4	0.31	88	6	6	33	44
47.	80-100	30	5.4	2.52	81	10	9	47	42
Pala									
48.	0-20	28	5.5	1.13	87	6	7	40	38
49.	20-40	29	5.6	1.36	84	7	9	42	38
50.	40-60	33	5.5	1.13	84	8	8	39	35
51.	60-80	23	5.2	0.96	79	10	11	43	44
52.	80-100	20	5.6	0.57	81	9	10	42	41
Paravur									
53.	0-20	3	5.1	1.06	93	2	5	34	44
54.	20-40	1	5.6	0.39	94	2	4	33	43
55.	40-60	2	6.6	0.37	94	2	4	33	42
56.	60-80	1	7.0	0.34	95	1	4	36	43
57.	80-100	0.6	7.0	0.31	94	2	4	35	43
Thodupuzha									
58.	0-20	27	5.8	2.15	78	13	9	49	43
59.	20-40	26	5.3	1.33	80	9	11	48	42
60.	40-60	17	5.2	1.16	83	8	9	37	46
61.	60-80	35	5.3	0.96	79	9	12	44	45
62.	80-100	39	4.8	0.48	81	8	11	45	45
Thripunithura									
63.	0-20	46	7.2	1.13	80	9	11	43	53
64.	20-40	34	7.4	1.63	88	6	6	38	50
65.	40-60	27	7.5	2.31	93	3	4	47	52
66.	60-80	40	7.3	2.02	93	3	4	41	48
67.	80-100	52	7.8	0.84	81	9	10	33	37

WHC = Water Holding Capacity; PS = Porosity

Table. 20 Chemical characteristics of the leachates from the municipal waste dumping sites

Site	pH	Na	K	Mg	Ca
		(Conc. mg/l)			
Kodungalloor:					
Leachate	6.2	61	25.61	18.89	5.875
Well water	5.4	36.1	11.46	9.01	1.231
Kottayam:					
Leachate	6.9	35	102.64	24.34	13.65
Well water 1	5.5	18.1	21.54	10.41	0.527
Well water 2	5.8	17.2	11.64	7.31	-1.065
Alapuzha:					
Leachate	7.1	161	807.87	60.27	16.86
Well water 1	7.2	25.9	70.97	14.69	7.348
Well water 2	6.7	19.6	21.51	10.47	9.326
Paravoor:					
Leachate 1	7.4	60.9	411.26	39.26	15.875
Leachate 2	7.8	49.3	244.19	32.49	10.541
Leachate 3	7.2	31.4	162.67	44.25	30
Leachate 4	7.3	39.3	47.94	13.53	15.182
Irinjalakuda:					
Leachate	7.1	34.1	66.99	25.36	13.635
Well water 1	4.6	51.3	61.63	15.87	1.480
Well water 2	5.6	41.4	5.1	3.2	-1.114
Changanassery:					
Leachate	7.2	207.9	812.58	65.2	17.599
Well water 1	6	47.9	62.27	14.22	4.144
Well water 2	4.5	51.5	109.53	9.11	3.987
Aluva:					
Leachate	6.5	66.3	202.89	37.59	3.215
Well water 1	5.1	36.1	40.99	17.38	0.401
Well water 2	5.5	6.5	16.32	5.03	-0.583
Kayamkulam:					
Leachate	7	249.7	275.29	14.96	1.372
Well water 1	6.4	49.7	18.85	15.52	12.593
Well water 2	6.5	37	26.92	13.13	8.979
Maximum permissible limit				30.00	75.00

The substratum composed of over 90% of sand in sites such as Alapuzha, Chertala, Kayamkulam and Paravur pose a threat of faster rate of leaching of contaminants into the ground water. Substratum composed of higher gravel content at sites Moovattupuzha, Irinjalakuda and Aluva even though had a lateritic substratum, the rate of leaching can be faster, which could be hazardous as the drinking water sources are affected.

Table 21. Analysis of heavy metals (conc. mg/l) in the leachates from municipal waste dumping sites

Site	pH	Copper	Manganese	Nickel	Lead
Alapuzha:					
Leachate	8.6	0.003	ND	ND	ND
Well water	7.2	0.018	ND	ND	ND
Kayamkulam:					
Leachate	8.5	0.001	0.002	ND	ND
Well water	7.8	0.022	ND	0.018	0.048
Kottayam:					
Leachate	8.4	0.024	0.021	0.312	0.429
Well water	7.1	0.006	0.004	ND	ND
Aluva:					
Leachate	8.2	0.004	0.003	0.016	0.024
Well water	7	0.01	0.003	0.064	0.071
Maximum Permissible limit (mg/l)		0.05	0.1	--	0.1

only one value is higher

2.5. Chemical characteristics of the leachates at municipal waste dumping sites

Leachates from the municipal sites were analysed to find out the chemical characteristics. Concentration of Sodium, Pottassium, Magnesium and Calcium were analysed. The leachates at Changanasseri were the maximum polluted one with significan high concentrations of all the tested parameters followed by Alapuzha, Paravoor, Aluva and Kayamkulam. Concentrations of Sodium is found to be high in the leachates of Kayamkulam and Changanasseri. Pottassium is found to be very high in Alapuzha and Changanasseri. Concentrations of Magnesium is found to be high in Alapuzha and Changanasseri and calcium in Alapuzha, Paravur and Changanasseri. Eventhough dumping at Changanasseri is identified to be the maximum polluted one, tested parameters indicated the well water (drinking water sources with in 200 meters to be safe, with Mg and Ca with in permissible limits. This site has hard laterite substractum below 80 cms (from the horizon). Well waters at all tested sites were found to be safe (with in the permissible limits) with relatively high concentrations of Pottassium in the wells of Alapuzha and Sodium in Kayamkulam which was also found to be high in the leachates at these sites (Table 20).

2.6. Heavy metals in municipal wastes

Well waters in homesteads which is the source of drinking water were tested. Results show the drinking water to be safe with concentrations in permissible limits. Concentration of heavy metals were more in well water than the leachates in most of the samples. Dumpings in Kottayam had traces of all the heavy metals tested in the leachates in highest concentrations at all sites. Drinking water in Aluva and Kayamkulam showed evidence of accumulation of heavy metals with relatively higher concentration.

3. IDENTIFICATION OF HOT SPOTS

3.1. Conservation hot spots

3.1.1. Flora

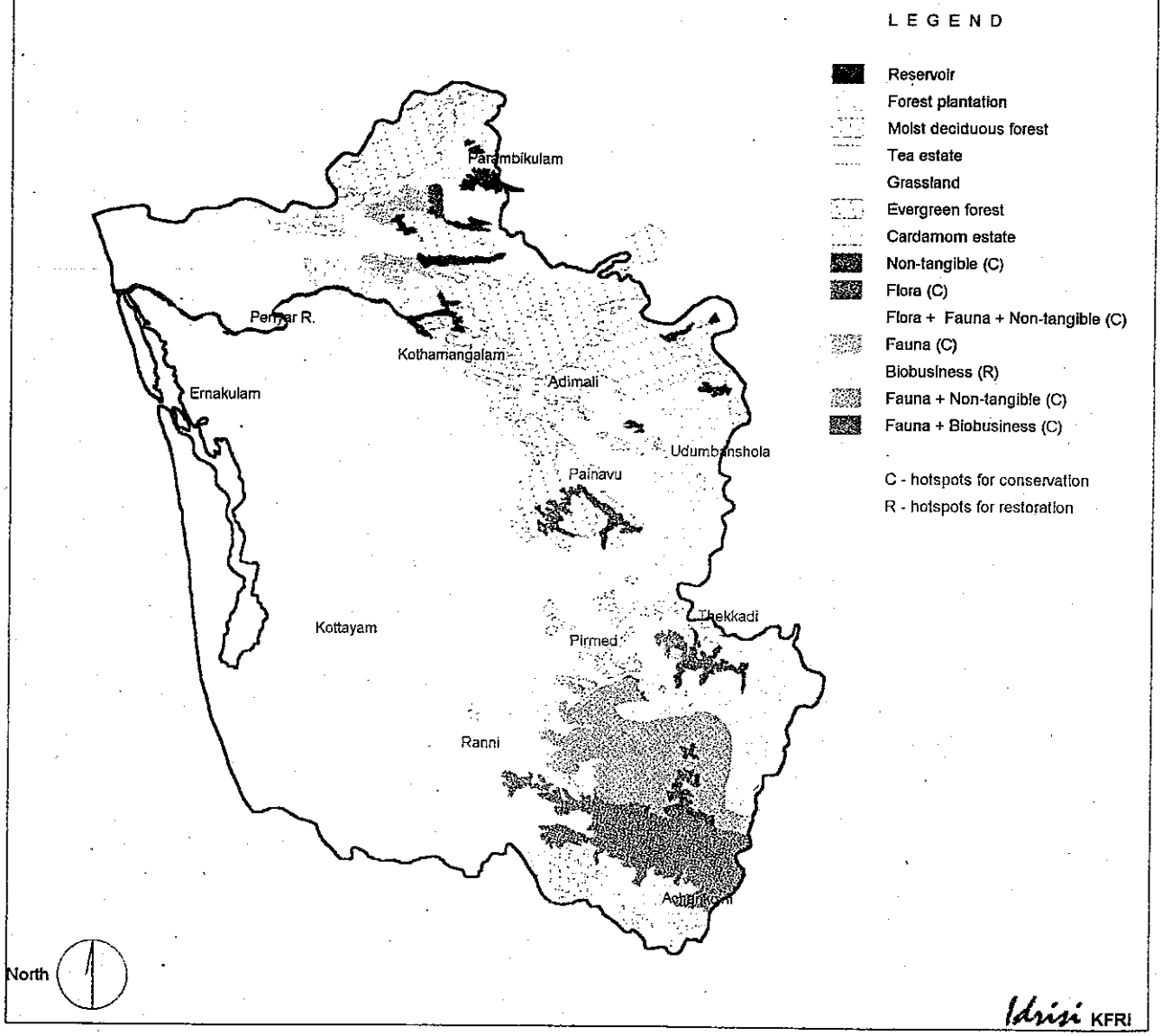
Among the floristically rich areas in the region, the areas of high conservation value is identified. Criteria for selection of hotspot for flora are in terms of number of angiosperms recorded from the area, exclusive species ie., species which are recorded to be present in only one particular area in the region, and number of species under endemic, rare, threatened, vulnerable or endangered categories. Recent publications were used for this purpose (Table 22).

Table 22. Criteria for selection of hot spot - FLORA

Sl No	Area	Angio-sperms	Exclu-sive	%	End-emic	%	Rare/ threatened/ vulnerable/ endangered	%	Source
1.	Periyar Tiger Reserve (PTR)	1965	777	39.54	515	26.20	150	7.63	Sasidharan, 1998
2.	Pathanamthitta	1250	202	16.18	253	20.24	175	14.00	Anilkumar, 1993
3.	Thrissur	1200	162	13.5	258	21.5	51	4.25	Sasidharan, 1994
4.	Eravikulam	274	138	50.36	62	22.63	29	10.58	Karunakaran, 1997
5.	Kottayam	885	211	23.84	--	--	--	--	Antony, 1989

Periyar Tiger Reserve with maximum number of angiosperms and exclusive species with 26 percent endemic species and 8 percent species under rare and threatened categories with largest and contiguous ~~patches of~~ evergreen forests is considered as the floristic hot spot in the region.

Fig.22.Hot spots in the region



3.1.2. *Fauna*

Among the faunistically rich areas in the region, attempts were carried out to find out the hot spots of conservation value in terms of habitat preferences of a wider array of larger mammals. Wildlife census of the state conducted by the Kerala Forest Research Institute and Kerala Forest Department in the year 1993 is used for the study. Relative density of sixteen mammals in different areas of the region was estimated (Table 23). The area with high population density of each species is identified and a score is assigned. Hence higher cumulative score assigned for an area will indicate highest density of more number of species in any area. The contiguous forests of Vazhachal and Malayattoor and the forests of PTR and Ranni support high faunal diversity with relatively high density. These areas in the region deserves immediate attention in terms of relatively high habitat preference of highly dense and diverse fauna. This area is considered to be a hot spot of high conservation value.

Table. 23. Criteria for selection of hotspots – FAUNA
(Relative density of sixteen mammals in the region)

	*Lion tailed mac-aque	*Bonnd Macaque	*Nilgiri Langur	*Comm-on langur	*Elephant	**Gaur	**Sambar	**Spotted deer	**Barking deer	**Mouse deer	**Wild boar	**Sloth Bear	**Wild dog	**Porcu-pine	**Small Indiancivet	**Toddy cat
Nenmara	11.1	3.7	0.5	--	1.4	0.6	1.14	0.62	1.57	1.25	2.31	10.95	2.92	0.49	1.19	--
Parambikulam	11.1	3.1	4.4	--	1.7	36.7	9.15	7.79	2.79	2.22	3.32	18.99	2.77	2.79	9.89	--
Thrissur	--	3.1	--	--	--	0.82	15.63	20.53	4.87	6.38	3.69	26.84	6.38	27.37	48.41	--
Chalakkudy	3.7	7.1	0.8	--	0.5	0.36	3.5	--	2.75	0.96	4.78	--	15.85	6.65	--	--
Vazhachal	22.2	15.7	10.7	--	7.8	10.4	1.89	4.06	43.31	6.70	2.44	--	16.18	2.24	3.23	10.43
Malayattoor	7.4	8.6	0.5	--	7.2	0.13	13.11	--	5.57	10.51	8.27	1.27	8.32	4.57	10.33	13.03
Kothamanagalam	--	4.8	--	--	2.3	--	6.18	--	3.61	10.76	5.96	6.78	--	1.75	1.74	3.51
Mankulam	--	1.2	--	--	--	32.64	5.37	--	5.57	4.59	5.24	9.51	6.33	2.63	2.58	16.68
Munnar	3.7	14.4	6.9	--	8.6	3.15	0.81	0.94	5.65	7.66	--	--	--	2.15	--	2.84
Idukki (WL)	--	9.03	4.2	100	5.3	8.02	8.4	62.26	4.96	15.32	8.16	2.02	13.93	22.98	14.95	5.84
Kottayam	3.7	4.5	--	--	1.4	0.06	9.02	0.94	5.14	7.96	3.39	1.18	1.57	3.98	1.79	5.72
Periyar Tiger Reserve	22.2	2.8	64.2	--	33.9	6.6	8.83	--	2.77	6.13	3.75	17.42	9.61	10.75	5.22	18.19
Ranni	14.8	15.7	7.9	--	23.9	0.25	11.65	--	8.05	16.99	45.16	3.87	9.56	10.44	0.65	19.39
Konni	--	6.1	--	--	6.1	0.19	5.31	2.86	3.39	2.55	3.53	1.17	6.55	1.26	--	4.37

d on Wildlife census conducted during 1993 by the Kerala Forest Research Institute in collaboration with the Kerala Forest Department

3.1.3. Non Tangible benefits

Goods and services provided (value Rs. in crores) in relation to the growing stock, extent of forests and environmental value of dense evergreen forests is estimated (Table 24). Contiguous evergreen forest patches of Ranni and Periyar Tiger Reserve together alone contribute goods and services worth 45 percent of the total value provided from the study region and hence is a hotspot of high conservation value.

Government of India assign an environmental value of Rs. 126.74 lakhs per hectare over a period of 50 years of fully stocked tropical forests for benefit cost estimates of development projects. The same as been adopted to calculate environmental value of fully stocked dense evergreen forests of each area in the region. The assumed average growing stock of timber in each vegetation type of the State and its average value (Nair, 1997) has been used for this purpose (Table 24).

Table 24. Criteria for selection of hot spots – NON TANGIBLE BENEFITS

Goods and services provided (value Rs. in crores) in relation to the growing stock, extent and environmental value of dense evergreen forest

Sl. No.	Forest Division	Value of the growing stock (Rs. In crores)	Environmental value (Rs. in crores)	Total value (Rs. in crores)
1.	Ranni	5776.74	50603.48	56380.22
2.	PTR	4507.52	42593.51	47101.03
3.	Malayattoor	3419.88	27910.68	31330.56
4.	Vazhachal	2088.17	25872.70	27960.87
5.	Munnar	3212.04	23983	27195.04
6.	Kothamangalam	1271.48	5979.59	7251.07
7.	Chalakkudy	819.51	6297.71	7117.22
8.	Achankoil	1340.38	4381.40	5721.78
9.	Parambikulam	1602.78	3757.84	5360.62
10.	Mankulam	396.45	4069.62	4466.07
11.	Kottayam	1383.99	2590.56	3974.55
12.	Eravikulam	162.68	2402.99	2565.67
13.	Idukky	438.38	1316.83	1755.21
14.	Nenmmara	1168.13	373.88	1542.01
15.	Konni	1266.69	--	1266.69
16.	Thattekkad	245.45	192.64	438.09

1. Based on the area estimates of forest types
2. Value estimates from (Source) Nair, T.K.R. 1997. The forest wealth of Kerala (eds.) Biodiversity and Topical forests. The Kerala scenario K. Pushpangadan and K.S.S. Nair, 1997. STEC, Kerala. pp. 127-131.

3.2. Restorative hotspots

3.2.1. Tangible benefits

Collection of Non Wood Forest Produce NWFPs is a major component in the economy of tribal communities. These forest dwellers are granted the exclusive right of collection. These items are marketed through Girijan Service Co-operative society (GSCS). Information regarding various items collected by the forest dwellers in each area during the past years and income generated through marketing is compiled. Higher dependency of these forest dwellers in terms of their income being substantiated through this activity and quantity of items being harvested reveal that there has been an immense pressure on the resource base on a selected few items. Criteria for selection of the restorative hotspot is to identify the area where intense pressure on the resource base exist which will lead to deterioration or local extinction of the species. Income from this activity is the major source of income to the forest dwellers for subsistence.

Table. 25. Criteria for selection of hot spots - TANGIBLE BENEFITS

Revenue (Rs. in million) accrued through collection of Non Wood Forest Products

Area	Rs. (in millions)
Sholayar	1.4
Palappally	0.61
Kuttampuzha	0.57
Devikulam	0.56
Kosadi	0.54
Adimali	0.42
Vazhathope	0.19
Nelliyampathy	0.18

Based on data from the collection depots of Girijan Sahakarana Co-operative Society

Forests in and around Sholayar has provided produce worth 1.4 millions (mean annual average) for the forests dwellers in this area (Table 25). Resin is the item which has provided majority of the income. Depletion of resources due to over

harvesting is an emerging threat to the resource base. To strike a balance between the maintenance of subsistence for livelihood of the forest dwellers and maintenance of ecosystem integrity is a challenge. Present marketing system is redundant and non enterprising which has affected the livelihood of forest dwellers in the region. Low returns from harvesting these products has persuaded them to forage more to meet subsistence for livelihood. This has also resulted in over harvesting, early harvesting and destructive harvesting which has affected the resource base leading to forest degradation. Hence this area (forest patches in and around Sholayar) with maximum activity of collection and marketing is considered as a restorative hot spot warranting immediate attention.

4. Management Plan

Proposed Ninth Five Year plan for the forestry and wildlife sector with focus on action oriented programs in the study region is analysed. The broad heads and its outlay during the year 1997-2002 are given in table 26.

Table. 26 Proposed activities and its outlay

Sl. No	Plan	Out lay 1997-2002 (Rs. in crores)
1.	Rational Forest Landuse	8
2.	Improved Management of Natural Forests	80
3.	Improving Forest Resource Base	19
4.	Efficient Utilization of Forest Resources	1
5.	Strengthening Forest Resources Conservation	30
6.	Enhanced contribution of Forests to community welfare	1
7.	Forest Research	1
8.	Strengthening Institutions	0.5
9.	Monitoring and Evaluation	0.5

Rational forest land use implies assessment of the available land resources, its pattern of utilisation, identification of incompatible uses, prevention and wastage of resources, assigning priorities in optimal use of resources and management of judicious resources and ensuring its sustainability. Important activities under this head are functional classification of forest lands which involves capability survey, collection, storage, analysis and processing of information on forest lands like inventory of resources, development of GIS/MIS etc., preparation of plans, resource budgets and purchase of equipments for these purposes. The outlay is eight crores.

Improved management of natural forests has maximum allotment of funds with an overlay of 80 crores. Major activities proposed under this head are forest management by zones, protection of natural forests, rehabilitation of degraded forests, soil and water conservation, enhancement of productivity of Non Wood Forest Produces, management of fragile ecosystems like mangroves and sacred groves in the non forested areas, regeneration of desired species in the degraded sites.

Improvement of forest resource base has an outlay of 19 crores for enhancing site and soil productivity of plantations, enhancement of agroforestry, community forestry and homestead forestry and for expansion of forest areas by acquisition.

For the enhancement of efficient utilisation of forest resources the outlay is one crore. Major tasks are to maximise production and efficient use of wood, Non Wood, alternate wood products and to introduce value added products for better economic returns. Strengthening Forest and Wildlife conservation has an outlay of 30 crores. This has an objective to develop and implement a comprehensive and integrated programme for improving forestry biodiversity conservation in the state for the posterity and for the sustainable ecological functions. The main operational and associated objective of the bio diversity conservation component of the activities, would be establishing an integrated state-wide strategy through strengthened capacity and increased opportunities for planning and management of the totality of habitats and eco systems within the Estate. Protecting ecosystems with in wildlife sanctuaries and communication systems, environmental education upgrading amenities and interpretation programmes, training and capacity building for improved bio-diversity management and enforcement of laws for preventing poaching and illegal trade are the activities contemplated under the scheme. Besides development of wildlife sanctuaries and national parks, activities like, wiidlife research, wildlife preservation, new sanctuaries and parks, watchers and guards among tribals etc. are also included under this broad category.

Enhanced contribution of forest to community welfare is through PFM, providing employment, introducing income generating activities, development of eco villages and social welfare schemes like housing, social infrastructure development, health care, employment in forestry activities, cottage and traditional industries. Urban forestry is also an important activity in this major head enabling to enhance the environmental and aesthetic values in urban areas. The key elements are peoples involvement, landscape planning, tree planting and development of institutions. Total outlay for these activities is one crore.

While forest research has an outlay of one crore, strengthening of institutions and monitoring & evaluation has an outlay of half crore each.

Strengthening of institutions is to bring substantial changes in the State's forest policy framework which of weaknesses such as market is now characterized by a number distortions, disincentives to good forest management, forest resources use etc. These reforms which, as whole, would create an enabling environment for the sector to grow and perform better in the future. The Plan should support institutional reforms by enabling KFD to concentrate its activities in three core areas identified (conserve the forest and its bio-diversity, provide forest products to local communities and industries and to improve livelihood of tribals and other poor people who live in and around the forest) instead of attempting to do everything in the forestry sector. Other objectives are to encourage KFD progressively to share some of its present responsibilities and benefits by forming partnerships with local people, NGOs, private sector, panchayats and other suitable government agencies with a stake in forestry. To promote professionalism in KFD by encouraging specialisation through international and external training of its staff and by bringing in experts on contract, in areas where it has limited or no expertise. To streamline the working of KFD through a process of reorganisation or redeployment of staff, delegation of managerial authority and accountability to lower levels and promoting career development. For this purpose, department is to review and propose changes to KFD's current functions, staff levels and skills.

management structures, administrative procedure and coordination within the organisation and with other government agencies.

Among the proposed activities maximum outlay is for the improvement of management of natural forests with an amount of 80 crores of rupees for 5 years followed by strengthening forest resource conservation with focus on biodiversity conservation through Protected Area networks. Unfortunately areas like benefits for community welfare, strengthening institutions and management of NWFPs has been overlooked in terms of allotted money.

82 NWFPs commercially exploited from this region have been marketed through Girijan Sahakaran Co-operative Societies (GSCS). 500 species providing NWFPs are found in Kerala forests (Nambiar *et al.*, 1985). There is an increasing demand for medicinal plants and plant products for industrial uses. Existing marketing mechanism is redundant and non enterprising. Fixing floor prices of these items, exploring the possibilities of value addition through semi processing has immense scope. There is a wider group of people, industries and end users outside the forest, dependent on these resources. Hence sustainable extraction from forest, regulating yield, processed for value addition can generate higher income for the forest dwellers which might help in forest conservation through controlling the existing unscientific and unsustainable practices like over harvesting, early harvesting and destructive harvesting depleting the resource base. Strengthening of NWFP based institutions with the help of better marketing and income generating opportunities can enhance social well being and ecosystem integrity.

A watershed based development approach involving soil and water conservation, rehabilitation of degraded forests through Assisted Natural Regeneration (ANR) along with reeds and bamboo, increasing the productivity of existing plantation forests is warranted in degraded areas of territorial divisions. The management of Protected Areas (PAs) has to be dealt with slightly different objectives. Maintenance of ecosystem integrity with conservation of biodiversity

on one hand and maintenance of livelihood of forest dwellers depending on forests for subsistence on the other is a major challenge. Attempts to strike a balance has to initiate efforts for strengthening of institutions, enhancement of livelihood activities through linking biodiversity based micro enterprises.

The areas with in the region can be categorised according to the type of the proposed managerial inputs as territorial divisions, Protected Areas, and Periyar Tiger Reserve (PTR) (Table 27). Areas coming under the Territorial Divisions are forest tracts of Chalakudy, Vazhachal, Malayattoor, Munnar, Mankulam, Kothamanglam, Kottayam, Ranni, Konni and Achenkoil. Areas coming under Protected Area are Iddukki Wildlife Sanctuary, Thattekad bird Sanctuary and Eravikulam National Park. In Periyar Tiger Reserve, under Ecodevelopment Project of Global Environment Fund and International Development Agency, the action plan, which has initiated has a set of site specific objectives.

Table. 27 Activities proposed in the study region

Area	Activities
Territorial Divisions 1. Chalakkudy 2. Vazhachal 3. Malayattoor 4. Munnar 5. Mankulam 6. Kothamangalam 7. Kottayam 8. Ranni 9. Konni 10. Achenkoil	1. Protection of natural forests 2. Rehabilitation of degraded forests 3. Management of Plantation forests 4. Assisted Natural Regeneration 5. Regeneration of Reeds and bamboo
Protected Areas 1. Idukki 2. Thattekad 3. Parambikulam 4. Eravikulam	1. Conversion of existing plantation to natural forests 2. Participatory Protected Area management 3. Rehabilitation programmes and Socio-Economic Development. of local community 4. Habitat improvement works 5. Ecotourism 6. Ecological Monitoring and Research 7. Biodiversity Protection
Periyar Tiger Reserve	*GEF/IDA Ecodevelopment Project* 1. Local level participatory planning, management protection 2. Improvement in Quality of life 3. Creating awareness for biodiversity conservation 4. Fisheries Management

References

Anilkumar, N. 1993. Floristic studies of Pathanamthitta. Ph.D thesis. (unpublished) University of Calicut.

Antony, V.T. 1989. Systemic studies on the flora of Kottayam district, Kerala. Ph.D thesis (unpublished) Bharathiar University, Coimbatore.

Ballick, J.M and R. Mendel Sohn, 1992. Assessing the economic value of traditional medicines from tropical rain forest. Conserve. Bio. 6. 128-130.

Census Report. 1991. Government of India.

Green Peace. 1999. Toxic hot spots: A Green peace investigation of Hindustan insecticides Ltd. Udhyogmandal, Kerala.

Hall, P and Bawa, K.S. 1993. Methods to assess the impact of extraction of Non Timber Tropical Forest Products on plant populations. Economic Botany. 47: 234-247.

Jahnige, P.J., Loomis, S.J., and Grumes, A.P. 1993. Valuing Non Timber Forest Products. A study of the Economic value of products from the Primary forest of the upper Napo province Equador, Tropical Resources Institute working paper. Yale school of Forestry and Environmental Studies New Heven.

Jayaraman, K. 1995. Structural dynamics of teak stands in Kerala. Final report of Research Project KFRI 147/92.

Jayaraman, K and Krishnankutty, C.N. 1990. A data bank for forestry sector in Kerala. Kerala Forest Research Institute. Research Report 66. Peechi. 27pp.

Karunakaran, P.V. 1997. Ecological studies on the Grassland of Eravikulam National Park, Kerala. Ph.D thesis (unpublished) Saurashtra University, Rajkot.

KFRI, 1997. Productivity of teak and Eucalypt plantations in Kerala. KFRI consultancy report of research project. Kerala Forest Research Institute. Peechi. 250/96.

May, R.M. 1995. Diversity, Stability and Maturity in natural ecosystem with particular reference to tropical moist forests. Rome FAO. 9 pp.

Nameer, P.O. 1998. Checklist of Indian mammals. Kerala Forest Department and Kerala Agricultural University. 90 pp.

Nair, T.K.R. 1997. The Forest Wealth of Kerala. In: Pushpangadan, P and Nair, K.S.S. Eds. Biodiversity and Tropical Forests: The Kerala Scenario: The State Committee on Science, Technology and Environment. Kerala. pp 127-131

Nair, K.S.S. and Easa, P.S. 1997. Animal Biodiversity in Kerala Forests. In: Pushpangadan, P and Nair, K.S.S. Eds. Biodiversity and Tropical Forests: The Kerala Scenario: The State Committee on Science, Technology and Environment. Kerala. pp 87-102

Nambiar, V.P.K., Sasidharan, N., Renuka, C and Balagopalan, M. 1985. Studies on the medicinal plants of Kerala Forest KFRI Research Report No. 42. 200 pp

Peters, C.M., Gentry, A.H and Mendelsohn, R. 1989. Valuation of an Amazonian Rain Forest. Nature. 339, 655-56

Sasidharan, N. 1994. Flora of Trichur Forest Division. Ph.D Thesis. University of Calicut.

Sasidharan, N. 1998. 'Studies on the flora of Periyar Tiger Reserve'. KFRI Research Report No: 150. July 1998.

Thomas, P. and Bai, M. 1993. Marketing of Non Timber Forest Products (NWFP) and the tribal economy of Kerala. An Economy analysis. Journal of tropical forestry 9, 196-203.

Tewari, D.N., 1991. Research on Non Wood Forest Products. MFP news. Centre for minor forest products for rural development and environmental conservation. 1 (1): 1-2.

Wildlife Census-Kerala. 1993. Report of the Wildlife census. Kerala Forest Department and Kerala Forest Research Institute.

Appendix 1. Quantity of NWFPs collected (Kgs.)

1993	1994	1995	1996	1997	Total	Average
195761.850	297908.100	273998.080	268138.320	307256.860	1343063.100	268612.620

Appendix II. Seasonal flow of NWFPs (Kgs.)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
1993	26533.900	38077.550	16247.00	11224.450	6583.450	7986.400	13087.800	4641.950	8673.550	12320.550	25445.050	24940.200	195761.850
1994	43290.850	27609.150	35637.800	34035.850	15999.300	55194.150	19404.250	3412.050	7644.200	7938.450	11724.850	36017.200	297908.100
1995	43717.150	27898.360	49622.500	14708.450	37335.200	15737.250	10771.850	13333.850	13416.200	13079.900	11013.800	23363.300	273998.080
1996	44395.600	40541.700	41109.140	19868.330	21174.800	9133.850	8736.850	12178.500	11795.350	14716.150	23650.400	20897.600	268138.320
1997	44525.700	68293.500	37985.850	43359.100	12408.100	25266.900	5949.260	6737.260	17769.350	21107.800	8783.350	15069.800	307256.860
Ave-rage	40492.640	40484.110	36120.460	24596.500	18700.210	22663.710	11590.000	8060.910	11859.730	13832.570	16123.490	24057.620	

Appendix III. Area wise extraction of NWFPs (Kgs.)

Zone	1993	1994	1995	1996	1997	Total	Average
Adimaly	17381.900	79999.000	39497.700	27177.050	12452.100	176507.750	35301.550
Palappilly	31035.800	33749.050	30246.950	46299.200	90080.300	231411.300	46282.260
Sholayar	80584.950	61852.300	75377.370	71538.850	86906.300	376259.770	75251.954
Nelliyampathy	17753.500	13383.000	5128.500	9558.850	35157.800	80981.650	16196.330
Devikulam	4385.750	53884.000	44936.650	38594.600	30005.850	171806.850	34361.370
Kuttampuzha	26997.500	29104.950	65835.030	39147.000	33873.000	194957.480	38991.496
Vazhathope	16131.000	42536.800	20135.650	31300.650	24535.050	134639.150	26927.830
Kosady	182.300	1421.650	808.300	5270.530	12456.350	20139.130	4027.830

Appendix IV. Flow of selected NWFPs (Kgs.)

Product	1993	1994	1995	1996	1997	Total	Average
Resin	54332.900	69149.000	109641.700	66283.300	63992.100	363399.000	72679.800
Honey	18557.750	11846.400	23273.100	32599.350	2017.160	882935.760	17658.752
Shikkakai	51036.800	28387.000	73072.900	32148.850	106636.300	213281.850	58656.370
Cardomom	3080.000	1610.700	6755.700	5373.200	1434.900	18254.500	3650.000
Pathripoovu	3675.800	6935.500	3275.800	1685.300	5573.800	21146.200	4229.240

Appendix V. Area wise extraction of selected NWFPs (Kgs.)

Product	Adimaly	Palappilly	Sholayar	Nelliya-mpathy	Devikulam	Kuttam-puzha	Vazhat-hoppe	Kosady	Total
Resin	76563.000	6055.400	173126.350	--	65619.400	35596.850	31058.500	1621.600	389641.100
Honey	5975.300	25603.700	37885.700	571.200	17111.250	23571.000	2304.250	252.900	113275.300
Shikkakai	21255.000	80324.900	117451.500	28916.000	1902.400	27044.100	2166.100	7437.850	286497.850
Cardomom	--	1895.000-	16359.500	3080.000	--	--	--	--	21334.500
Pathripoovu	2342.050	2997.050	5661.250	1213.500	3905.050	2476.400	2550.850	--	21146.150
Total	106135.350	116876.050	350484.300	33780.700	88538.100	88688.350	38079.700	9312.350	831894.90

Appendix VI. Income generated through extraction of NWFPs (Rs.)

1993	1994	1995	1996	1997	Total	Average
2627532.20	3573721.30	5860339.80	4502308.50	4133825.40	20697726.00	4139545.20

Appendix VII. Seasonal fluctuations of income generated through extraction of NWFPs (Rs.)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
1993	193775.20	293059.00	237472.59	251430.75	168957.91	151449.24	251913.29	105220.00	191252.10	174283.90	223146.98	385571.55	2627532.20
1994	395319.10	138333.87	488693.73	433739.70	271681.40	337523.95	103312.55	16869.20	51777.95	338892.25	554863.80	442714.10	3573721.30
1995	610958.07	338954.20	1106683.90	372290.15	613330.61	323679.45	205506.85	527683.65	1075595.30	193336.80	154835.15	337486.10	5860339.80
1996	986821.97	761594.20	911968.75	344662.80	376120.35	165333.65	149660.00	201417.90	134474.20	240749.95	384131.30	240192.95	4502308.50
1997	569193.45	981846.25	663829.31	458691.45	333661.95	221810.15	139844.30	96700.80	193318.75	183353.15	118577.20	172998.50	4133825.40
Ave-rage	472119.70	502757.62	681729.62	372162.94	352750.42	240059.28	170047.39	189578.31	329283.61	226123.20	287110.88	315792.62	--

Appendix VIII. Income generated through extraction of selected NWFPs. (Rs.)

Product	1993	1994	1995	1996	1997	Total	Average
Resin	885817.11	976886.40	1673414.40	937922.70	1097604.70	5571645.30	1114329.00
Honey	458221.49	334016.00	1203645.20	1421926.10	750962.45	4168771.10	833754.22
Shikkakai	38670.65	240322.55	94541.10	404981.60	822789.00	1949341.50	389868.30
Cardomom	181027.50	305547.50	1291881.00	41368.40	22098.00	1841922.40	368384.48
Pathripoovu	142450.43	339498.00	136463.55	75709.80	396353.65	1090475.40	218095.08
Total	2054223.10	4392046.80	4399945.20	2881908.60	3089808.30	14622154.00	--

Appendix IX. Income generated areawise through NWFPs extraction (Rs.)

Zone	1993	1994	1995	1996	1997	Total	Average
Adimaly	234046.05	675069.80	584603.25	407701.05	211312.50	2112732.60	422546.52
Palappilly	414751.00	385517.50	502742.00	750333.45	1007445.40	3060789.30	612157.86
Sholayar	1264274.20	1596803.10	1352471.00	1190246.20	1608836.40	7102630.90	1402526.10
Nelliyampathy	212133.00	185386.80	110309.00	253986.25	153618.81	915433.86	183086.77
Devikulam	65765.28	499225.38	769413.77	852880.12	620890.10	2808174.60	561634.92
Kuttampuzha	274717.50	337373.00	1086006.40	858391.25	293006.00	2849494.10	569898.82
Vazhathope	185436.11	236913.40	141228.55	170578.20	215900.05	950056.30	190011.20
Kosady	2056.40	11378.65	16530.35	89562.30	152660.65	272188.35	544337.67
Total	2653179.40	3927667.50	456330.10	4573678.70	4263669.80	19981498.00	--

Appendix X. Income generated area wise through extraction of selected NWFPs (Rs.)

Product	Adimaly	Palappilly	Sholayar	Nelliya-mpathy	Devik-ulam	Kuttam-puzha	Vazhat-hoppe	Kosady	Total
Resin	949084.45	148323.31	3317773.10	--	854727.93	392409.86	362245.30	53028.40	6077592.20
Honey	256351.75	1040870.50	1449841.10	124375.00	204496.85	1081116.20	97546.55	11397.05	4265994.80
Shikkakai	272678.70	565876.00	980413.20	289916.00	15402.55	323864.00	22423.65	88455.20	2559029.20
Cardomom	--	133184.50	1699132.90	181022.50	--	--	--	--	201339.90
Pathripoovu	129392.95	163625.00	214953.50	51500.00	282487.60	104805.55	143711.05	-	109047.60
Total	1607507.80	2051879.30	7662113.80	646813.50	1357114.80	1902195.50	625926.55	152880.65	16006429.00

Appendix X1. Fluctuation in prices of selected NWFPs (Rs./Kg.)

Product	1993	1994	1995	1996	1997
Resin	18.07	17.15	15.93	15.56	19.47
Honey	27.43	28.33	51.73	45.87	43.76
Shikkakai	7.57	9.89	11.49	12.00	8.38
Cardomom	40.62	48.94	41.52	44.45	71.11
Pathripoovu	100.13	199.97	199.39	147.66	174.18

Appendix 12. List of NWFPs extracted from the study site and its details

Local name	Botanical name	1993		1994		1995		1996		1997		1998	
		Qty. (kg)	Price (Rs.)	Qty. (kg)	Price (Rs.)	Qty. (kg)	Price (Rs.)	Qty. (kg)	Price (Rs.)	Qty. (kg)	Price (Rs.)	Qty. (kg)	Price (Rs.)
Ezhaku (I)	*Apies* sps.	70.45	17784.00	659.50	4097.10	947.30	35033.70	361.15	53291.80	1193.15	51035.05	4831.55	181241.65
Ezhaku (II)	*Apies* sps.	30.45	801.60	--	--	--	--	3.50	154.00	--	--	33.95	955.60
Lavati (seed)	*Hydnocarpus pentendra*	728.50	4364.60	3236.40	2048.20	162.50	1286.50	136.90	43360.80	1985.00	44092.80	9159.30	113586.90
Manchikai	*Sapindus laurifolius*	3264.15	25634.30	4273.90	20464.35	513.30	2106.60	828.50	3743.45	13776.60	15373.10	22656.45	205682.80
Kurunthotti (dry)	*Sida rhombifolia* (ssp. Retusa)	1373.30	8088.10	2800.05	18033.28	416.10	4776.80	429.50	2860.25	198.50	1526.60	5217.45	35285.03
Kurunthotti (fresh)	*Sida rhombhifolia (ssp. Retusa)*	260.00	780.00	--	--	--	--	1.00	5.00	--	--	261.00	785.00
Kattukurumalaku	*Piper nigrum*	3.70	46.25	165.00	9783.70	27.70	690.60	13.90	365.00	582.00	2394.00	792.30	13279.55
Kudampuli	*Garcinia gummigutta*	697.50	13997.85	73.00	1679.00	26.50	617.50	300.45	15.54	406.45	16482.00	1503.90	48316.35
Kurinthumpi (fresh)	*Strobilanthes ciliatus*	133.50	6432.00	273.20	1355.50	--	--	83.80	335.20	27.00	128.00	2517.50	8250.70
Kurinthumpi (dry)	*Strobilanthes ciliatus*	--	--	17024.50	2131.10	962.00	103.85	57.50	20365.10	--	--	23736.50	92881.20
Maali Kuru	*Palaquium ellipticum*	97.00	3122.25	41116.00	69558.55	--	--	--	--	--	--	41413.00	72680.80
Nadhana (flower)	*Cinnamomum verum*	--	--	1.30	19.50	4.40	12.20	--	--	--	--	5.70	31.70
Nechotti (skin)	*Symplocos cochinchinensis*	2328.50	6618.50	2194.00	9853.25	3248.50	17480.75	2655.50	15160.25	12431.60	56864.45	22858.10	105977.20
Nattinelia	*Acacia caesia*	--	--	4246.70	23136.85	1429.20	9355.45	14518.30	128532.90	25893.30	192975.75	46087.50	354000.95
Nattupadavalam	*Trichosanthes cucumerina*	4146.30	31366.55	28197.50	340762.60	9404.00	131656.00	19753.50	592133.00	6901.30	1202464.80	68420.60	2298382.90
Nellikkaya	*Emblica officinalis*	71517.30	1104.50	875.90	1442.45	986.30	2300.50	1946.00	13545.20	152.00	450.25	75495.10	18842.95
Nilinchi	*Alpinia galanga*	210.20	967.65	--	--	24.00	133.20	699.50	6804.00	--	--	933.70	7904.85
Payyanivenu	*Oroxylum indicum*	--	--	--	--	--	--	67.00	207.00	--	--	67.00	207.00
Pattuthippali veru	*Piper longum*	982.10	1380.20	876.20	5075.55	895.10	5 722.40	1076.10	22772.60	903.00	7040.50	4732.50	41991.25
Pulamuthukku kezhengu	*Ipomoea mauritiana*	36.00	72.00	--	--	--	--	3941.80	10338.50	401.00	1000.50	4378.80	11411.00
Ulampiri valampiri	*Helicteres isora*	6.00	7.20	8.00	9.60	16.00	16.00	3.00	9.00	727.00	--	33.00	41.80
Veerottikuru	*Croton tiglium*	--	--	--	--	--	--	998.00	7200.80	146.80	7124.00	1725.00	14324.80
Kandankoova	*Curcuma* sps.	2711.40	9637.65	347.20	8511.55	221.20	2362.40	2183.50	28710.70	--	1395.00	5610.10	50617.30
Vella Koova	*Curcuma* sps.	--	--	--	--	19.80	46.00	100.00	655.20	107.80	--	119.80	701.20
Kanjiram (seed)	*Strychnos nuxvomica*	--	--	452.50	2594.10	--	--	--	--	--	332.00	560.30	2926.10
Kalkizhangu	*Cyclea peltata*	10.10	42.45	--	--	--	--	5.80	34.80		--	50.90	77.25
Kuttheri chunda (fresh)	*Solanum indicum*	--	--	--	--	--	--	--	--	547.00	2246.00	547.00	2246.00
Urila	*Desmodium velutinum*	93.90	465.20	626.60	4629.20	--	--	3959.70	36571.10	3463.25	31151.25	8143.45	728116.75
Urila (fresh) (ii)	*Desmodium velutinum*	--	--	--	--	--	--	253.90	1762.80	267.40	2053.70	50011.30	3816.50
Manjal	*Curcuma aromatica*	--	--	--	--	49.10	248.65	--	--	--	--	49.10	248.65
Vadukuruu	*Tamarindus indica*	--	--	5546.00	8319.00	--	--	--	--	--	--	5546.00	8319.00
Vattu inchi	*Zingiber zerumbet*	--	--	20.00	90.15	--	--	--	--	--	--	20.00	90.10
Vayalthiru	*Holostemma adilkodium*	--	--	4.00	30.00	--	--	--	--	--	--	4.00	30.00
Vayyanam	*Pavetta indica*	--	--	--	--	3000.00	9000.00	--	--	--	--	3000.00	9000.00

Appendix 12. List of NWFPs extracted from the study site and its details (Contd.....)

Local name	Botanical name	1993		1994		1995		1996		1997		1998	
		Qty. (kg)	Price (Rs.)	Qty. (kg)	Price (Rs.)	Qty. (kg)	Price (Rs.)	Qty. (kg)	Price (Rs.)	Qty. (kg)	Price (Rs.)	Qty. (kg)	Price (Rs.)
Adalodakam	*Adathoda zeylanica*	--	--	--	--	252.00	766.00	--	--	--	--	252.00	766.00
Enthapanakkai	*Cycas* sps.	--	--	--	--	4.50	45.00	73.50	612.00	--	--	78.00	657.00
Enmarchi veru	*Cimelia arborea*	--	--	--	--	92.00	368.00	2020.00	7296.50	--	--	2112.00	7664.50
Vayampu	*Acorus calamus*	--	--	--	--	--	--	347.00	3407.00	--	--	347.00	3407.00
Thumba veru	*Leucas* sps.	--	--	--	--	--	--	332.00	7250.00	--	--	332.00	7250.00
Kasthurimanjal	*Curcuma aromatica*	25907.75	205392.30	30358.60	350510.95	22610.73	212592.65	27726 .70	296275.85	10863.40	87386.25	117467.18	1152157.90
Thelli (I)	*Canarium strictum*	30315.30	533779.00	28378.40	478020.20	67071.65	1072767.70	34869.00	551221.85	42850.80	846567.45	203544.47	3514016.90
Thelli (II)	"	23843.65	320322.35	30607.70	401246.20	24045.65	496580.90	26555.95	32383.85	14519.50	216151.10	119572.45	1466683.70
Thelli (III)	"	0.250	6.25	5.00	150.00	344.50	8265.00	909.80	9903.55	167.75	4216.25	927.30	22341.05
Thellivella	"	--	--	--	--	26.00	556.60	--	--	42.30	1023.65	68.30	1580.25
Thaen	*Apies* sps	18557.75	458221.49	117446.40	335958.50	23284.10	1204310.70	32599.35	1421426.10	20126.60	689584.95	136818.35	4110001.60
Cheruthaen	"	731.45	44834.40	108.20	7123.40	1387.70	82499.32	1915.00	124324.60	870.80	76534.35	5013.15	335316.07
Cheevakai (dry)	*Acacia concinna*	51036.80	386706.65	23802.00	235737.55	73061.90	938751.60	33853.35	404981.60	93657.30	837611.60	275411.25	2803789.00
Pathripoovu	*Sterospermum colais*	3675.80	142450.43	6937.50	339498.00	3275.800	136463.55	1685.30	75709.80	5573.80	396353.65	21146.20	1090475.40
Kunkilliyam	*Boswellia serrata*	585.00	9900.00	758.00	66025.00	328.50	48209.00	515.20	18333.25	523.80	44258.81	2710.50	177816.06
Maramanjal	*Coscinium fenestratum*	2152.60	8509.95	24316.90	96370.95	2653.90	13541.40	6793.70	40103.45	1799.70	12515.30	37716.80	171041.05
Naruneendi	*Hemidesmus indicus*	5.35	53.50	--	--	1.50	9.60	--	--	--	--	6.80	62.50
Moovila	*Pseudodarthrea viscida*	4.50	39.60	243.00	243.00	--	--	--	--	--	--	29.10	282.60
Manjakkova	*Curcuma angustifolia*	63.10	757.20	4623.20	4623.20	12.40	158.30	251.33	3240.00	200.35	3552.00	908.43	12330.70
Kattupayar	*Vigna trilobata*	--	--	60.00	60.00	--	--	--	--	--	--	12.70	60.00
Oldkuru	*Sarcostigma clanii*	--	--	20.00	20.00	174.00	4210.80	--	--	--	--	176.00	4230.80
Perimpoovu		--	--	--	--	15.00	235.60	8.40	554.40	31.50	2512.00	54.90	3302.00
Arattha	*Ruta graveolens*	--	--	--	--	--	--	181.50	1997.90	--	--	181.50	1997.90
Malainchi		--	--	--	--	--	--	16.00	112.00	--	--	16.00	112.00
Kazhanji kuru	*Caesalpinia bonduc*	2.00	17.00	--	--	--	--	12.50	240.00	3.00	240.0	17.50	497.00
Kopuvella	*Vareria indica*	1720.40	20644.80	1021.70	12277.20	130.90	15758.50	1236.30	15921.00	1122.00	15858.00	6409.40	80459.50
Pulthylum	*Cymbopogon flexuosus*	34.40	1692.00	2210.65	446842.10	10.35	1916.50	--	--	--	--	2255.40	454950.60
Puthiri chunda	*Solanum indicum*	466.00	1398.00	--	--	--	--	3100.00	16250.00	5361.00	18691.00	8927.00	36339.00
Padavala samoolam	*Trichosanthes cucumerina*	90.00	1350.00	--	--	--	--	--	--	--	--	90.00	13.50
Thanikka	*Terminalia bellirica*	25.00	25 .00	--	--	--	--	--	--	--	--	25.00	25.00
Pollakkaya (fresh)	*Anamirta cocculus*	50.00	100.00	--	--	--	--	--	--	--	--	50.00	100.00
Pollakkaya (dry)	"	100.00	200.00	--	--	--	--	--	--	--	--	100.00	200.00
Nellikai (fresh)	*Phyllanthus emblica*	8188.00	123012.00	429.00	1870.80	1087.00	2919.00	--	--	--	--	9704.00	127801.80
Nellikai (dry)	*Phyllanthus emblica*	24.00	96.00	--	--	--	--	78.00	780.00	--	--	102.00	876.00

Appendix 12. List of NWFPs extracted from the study site and its details (Contd.....)

Local name	Botanical name	1993		1994		1995		1996		1997		1998							
		Qty. (kg)	Price (Rs.)	Qty. (kg)	Price (Rs.)	Qty. (kg)	Price (Rs.)	Qty. (kg)	Price (Rs.)	Qty. (kg)	Price (Rs.)	Qty. (kg)	Price (Rs.)	Qty. (kg)	Price (Rs.)	Qty. (kg)	Price (Rs.)	Qty. (kg)	Price (Rs.)
Kattukodi	*Piper* sps	2715.50	9662.05	1947.20	7711.10	--	--	2.00	4.00	2588.00	10552.00	11917.40	27929.10						
Kattaratha	*Alpinia calcarata*	163.00	996.20	6.00	30.00	36.00	268.00	338.00	2312.50	--	--	543.00	3606.070						
Kolinchi	*Acacia* sps.	--	--	21.50	397.00	--	--	--	--	--	--	21.50	397.00						
Amalpori	*Rauvolfia serpentina*	6.95	208.50	--	--	--	--	46.80	3801.50	--	--	53.75	4010.00						
Kathavari	*Asparagus racemosus*	0.35	1.90	--	--	10587.50	28283.00	1038.40	37072.90	5600.00	22079.75	26571.25	87437.55						
Cherithekku	*Callicarpa tomentosa*	438.00	811.60	--	--	--	--	83.00	498.00	14617.50	32336.50	15138.50	33646.10						
Chittamruthu	*Tinospora cardifolia*	--	--	--	--	--	--	200.00	600.00	21.00	63.00	221.00	663.00						
Kadukka	*Terminalia chebula*	--	--	15626.00	390.65	--	--	--	--	4835.00	16922.50	20461.00	55987.50						
Plassu	*Butea monosperma*	--	--	--	--	--	--	2103.00	2589.50	1206.00	3998.00	3309.00	10587.50						
Cheevakkai (fresh)	*Acacia sinnata*	--	--	4585.00	4585.00	--	--	--	--	184.93	43972.00	23078.00	48557.00						
Cheevakkai (fresh)	*Acacia sinnata*	51036.80	386706.65	23802.00	235737.55	730061.91	938751.60	33853.35	404981.60	93657.30	837611.60	275411.35	2803789.00						
Vetturi	*Nothapodytes nimmoniana*	--	--	764.50	1261.40	1000.00	2000.00	2271.00	687.00	582.00	2394.00	4617.50	11742.40						

Appendix . 13. Vertebrate biodiversity of the State

Birds

Order	Family	No. of species
Podicipediformes	Podicipedidae	2
Procellariformes	Procellariidae	1
	Hydrobatidae	1
Pelecaniformes	Phaethontidae	1
	Pelicanidae	1
	Sulidae	2
	Phalacrocoracidae	4
	Fregatidae	2
Ciconiiformes	Ardeidae	15
	Ciconiidae	6
	Threskiornithidae	4
	Phoenicopteridae	1
Anseriformes	Ariatidae	12
Falconiformes	Accipitridae	33
	Falconidae	7
Galliformes	Phasianidae	12
	Turnicidae	3
Gruiformes	Rallidae	9
	Otididae	2
Charadriiformes	Jacanidae	2
	Haematopodidae	1
	Rostratulidae	1
	Recurvirostridae	2
	Dromadidae	1
	Burhinidae	2
	Glareolidae	3
	Charadriidae	37
	Sterocorariidae	1
	Laridae	20

Order	Family	No. of species
Coraciiformes	Alcedinidae	8
	Meropidae	4
	Coraciidae	2
	Upupidae	1
	Bucerotidae	4
Piciformes	Capitonidae	5
	Picidae	13
Passeriformes	Pittidae	1
	Alaudidae	7
	Hirundinidae	10
	Laniidae	4
	Oriolidae	3
	Dicruridae	6
	Artamidae	1
	Sturnidae	8
	Corvidae	4
	Campephagidae	11
	Irenidae	5
	Pycnonotidae	8
	Muscicapidae	76
	Paridae	2
	Sittidae	2
	Motacillidae	17
	Dicaeidae	3
	Nectariniidae	6
	Zosteropidae	1
	Ploceidae	11
	Total	**474**
Reptiles		
Crocodylia	Crocodylidae	1
Testudines	Emydidae	2
	Testudinidae	2
	Trionychidae	2
Squamata	Gekkonidae	22
	Agamidae	13
	Chamaeleonidae	1
	Scincidae	18
	Lacertidae	2
	Varanidae	1

Order	Family	No. of species
Squamata	Typhlopidae	5
	Uraeotyplilidae	23
	Boidae	2
	Colubridae	34
	Elapidae	6
	Viperidae	8
	Total	**142**
Amphibians Gymnophiona	Ichthyophidae	6
	Uraeotyplilidae	4
	Caecilidae	3
	Bufonidae	9
	Microhylidae	46
	Rhacophoridae	18
	Total	86
Fresh water fishes Clupeiformes	Clupidae	1
Anguilliformes	Anguillidae	2
Osteoglossiformes	Notopteridae	1
Cypriniformes	Cyprinidae	82
	Homalopteridae	19
	Cobitidae	4
Siluriformes	Bagridae	12
	Siluridae	5
	Schilibeidae	3
	Sisoridae	4
	Clariidae	3
	Heteropneustidae	2
Cyprinodontiformes	Hemiramphidae	3
	Belonidae	2
	Horaichthyidae	1
	Poecillidae	2
	Aplocheilidae	3

Order	Family	No. of species
Perciformes	Channidae	5
	Mastacembellida	3
	Nandidae	3
	Cichlidae	4
	Gobiidae	9
	Anabantidae	1
	Belontidae	2
	Osphronemidae	1
	Ambassidae	4
	Mugilidae	2
	Silangidae	2
	Leiognathidae	2
	Lobotidae	1
	Gerreidae	1
Syngnathiformes	Syngnathidae	1
Tetraodontiformes	Tetraodontidae	1
	Synbranchiformes	
	Synbranchidae	2
	Total	**196**

Source: Nair, KSS and P.S. Easa. 1997. Animal Biodiversity in Kerala Forests. In (eds.) Pushpangadan, P and Nair, KSS. 1997. Biodiversity and tropical forests. The Kerala Scenario. STEC. Kerala. pp – 92-101.

Action	Target date of completion	Remarks
Land Environment		
* Data on physico-chemical characteristics of soils in GKR	Dec. 31, 1999	enclosed
Biological Environment		
* Hotspot mapping, identification of limiting resources and detailed management plans	Dec. 31, 1999	enclosed
* Data on physico-chemical characteristics of soils in GKR	Dec. 31, 1999	enclosed
* Updating of soil erosion map	Dec. 31, 1999	Data from CESS Required
* Data on avi-fauna	Dec. 31, 1999	CESS report
* Institution wise modified consolidated report preparation covering the data gaps and incorporating the suggestions made in Thiruvananthapuram (May and Dec. 1999) and Kochi (Sep. 1999) meetings	Jan. 15, 2000	enclosed
* Sink potential index in GKR	Jan. 15, 2000	enclosed
* Consolidated Biological environment and resources report preparation incorporating all the above including Business as Usual (BaU) projections and environmental and resource management plans	Jan. 31, 2000	Under preparation
Natural Resources		
* Bio energy	Jan. 15, 2000	NA
* Fresh water biological resources	Jan. 15, 2000	enclosed
* Terrestrial flora and fauna	Jan. 15, 2000	enclosed
* Avi-fauna	Jan. 15, 2000	CESS report

ENCLOSURES

Attachments	Pages
1. Soil properties of GKR	18
2. Checklist of Mammals in the region	4
3. Algae associated with mangroves	1
4. Macro invertebrates	1
5. Phytoplanktons	2
6. Freshwater fishes	3

Physical and chemical properties of soil in GKR

DISTRICT : KOLLAM
DIVISION : KONNI

1. Perinthomoozhi, Naduvathumoozhi Range, Konni Forest Division. 1884 teak, level, well drained.

00-20 cm Dark reddish brown (5 YR 3/3), loamy sand, granular, friable, plentiful roots, slightly acid.

20-40 Dark reddish brown (5 YR 3/3), loamy sand, granular, friable, plentiful roots, slightly acid.

40-60 Dark reddish brown (5 YR 3/3), gravelly loamy sand, massive, slightly firm, plentiful roots, slightly acid.

	00-20	20-40	40-60	00-60
Gravel (g/kg)	*	*	*	*
Sand (g/kg)	800	760	750	770
Silt + Clay (g/kg)	200	240	250	230
Organic carbon (g/kg)	14	12	10	12
pH (20:40 water)	6.2	6.1	6.1	6.1
Exch. Acidity (mg/kg)	38	55	49	47
Exch. Bases (mg/kg)	144	132	126	134

* Uncorrected for gravel.

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2. Perinthomoozhi, Naduvathumoozhi Range, Konni Forest Division. 1963 teak (II), level, well drained.

00-20 cm Dark reddish brown (5 YR 3/3), loamy sand, granular, friable, plentiful roots, slightly acid.

20-40 Dark reddish brown (5 YR 3/3), gravelly loam, granular, friable, plentiful roots, medium acid.

40-60 Dark reddish brown (5 YR 3/3), gravelly loam, massive, slightly firm, few roots, medium acid.

	00-20	20-40	40-60	00-60
Gravel (g/kg)	*	*	*	*
Sand (g/kg)	810	750	740	770
Silt + Clay (g/kg)	190	250	260	230
Organic carbon (g/kg)	10	12	10	11
pH (20:40 water)	6.4	6.0	6.0	6.1
Exch. Acidity (mg/kg)	34	54	49	46
Exch. Bases (mg/kg)	163	148	142	151

* Uncorrected for gravel

3. Mannarappara, Naduvathumoozhi Range, Konni Forest Division. 1932 teak, 90 masl, rolling, pit on upper slope, well drained, plentiful undergrowth. Plot 1 of 500 m transect.

00-20 cm Dark reddish brown (5 YR 3/3), loam, granular, friable, plentiful roots, medium acid.

20-40 Reddish brown (5 YR 4/4), gravelly loam, massive, firm, very few roots, strongly acid.

40-60 Yellowish red (5 YR 4/6), gravelly sandy loam, massive, very firm, no roots, strongly acid.

	00-20	20-40	40-60	00-60
Gravel (g/kg)	170	350	430	320
Sand (g/kg)	620	460	440	510
Silt + Clay (g/kg)	210	190	130	170
Organic carbon (g/kg)	14	8	3	8
pH (20:40 water)	5.6	5.2	5.0	5.3
Exch. Acidity (mg/kg)	42	32	22	32
Exch. Bases (mg/kg)	100	52	40	64

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4. Mannarappara, Naduvathumoozhi Range, Konni Forest Division. 1932 teak, 75 masl, rolling, pit on upperslope, well drained, abundant undergrowth. Plot 2 of 500 m transect.

00-20 cm Reddish brown (5 YR 4/4), gravelly clay loam, granular, firm, plentiful roots, strongly acid.

20-40 Dark red (2.5 YR 3/6), gravelly clay loam, massive, very firm, few roots, strongly acid.

40-60 Red (2.5 YR 4/6), very gravelly clay loam, massive, very firm, no roots, strongly acid.

	00-20	20-40	40-60	00-60
Gravel (g/kg)	230	470	550	420
Sand (g/kg)	510	340	290	380
Silt + Clay (g/kg)	260	190	160	200
Organic carbon (g/kg)	13	5	3	7
pH (20:40 water)	5.4	5.1	5.1	5.2
Exch. Acidity (mg/kg)	44	23	15	27
Exch. Bases (mg/kg)	69	37	36	47

5. Mannarappara, Naduvathumoozhi Range, Konni Forest Division. 1932 teak, 70 masl, rolling, pit on midslope, well drained, abundant undergrowth. Plot 3 of 500 m transect.

00-20 cm Dark reddish brown (5 YR 3/3), gravelly loam, granular, slightly firm, plentiful roots, strongly acid.

20-40 Yellowish red (5 YR 4/6), gravelly clay loam, massive, firm, few roots, very strongly acid.

40-60 Red (2.5 YR 4/6), gravelly clay loam, massive, very firm, no roots, very strongly acid.

	00-20	20-40	40-60	00-60
Gravel (g/kg)	300	380	380	350
Sand (g/kg)	510	410	420	450
Silt + Clay (g/kg)	190	210	200	200
Organic carbon (g/kg)	12	6	4	7
pH (20:40 water)	5.3	5.0	5.0	5.1
Exch. Acidity (mg/kg)	39	35	25	33
Exch. Bases (mg/kg)	63	50	43	52

6. Mannarappara, Naduvathumoozhi Range, Konni Forest Division. 1932 teak, 60 masl, rolling, pit on midslope, well drained, abundant undergrowth. Plot 4 of 500 m transect.

00-20 cm Dark reddish brown (5 YR 3/3), gravelly sandy loam, granular, friable, plentiful roots, medium acid.

20-40 Dark reddish brown (5 YR ¾), gravelly loam, granular, slightly firm, plentiful roots, strongly acid.

40-60 Reddish brown (5 YR 4/4), gravelly loam, massive, few stones, very few roots, strongly acid.

	00-20	20-40	40-60	00-60
Gravel (g/kg)	230	210	370	270
Sand (g/kg)	580	580	440	530
Silt + Clay (g/kg)	190	210	190	200
Organic carbon (g/kg)	13	12	6	10
pH (20:40 water)	5.6	5.2	5.1	5.3
Exch. Acidity (mg/kg)	40	47	30	39
Exch. Bases (mg/kg)	85	55	50	63

7. Mannarappara, Naduvathumoozhi Range, Konni Forest Division, 1932 teak, 45 masl, pit on level, well-imperfectly drained, plentiful undergrowth. Plot 5 of 500 m transect.

00-20 cm Dark yellowish brown (10 YR 3/6), loam, granular, slightly firm, plentiful roots, medium acid.

20-40 Dark brown (7.5 YR 3/4), loam, massive, very firm, few roots, medium acid.

40-60 Dark reddish brown (5 YR 3/4), gravelly loam, massive, very firm, few roots, medium acid.

	00-20	20-40	40-60	00-60
Gravel (g/kg)	150	140	210	170
Sand (g/kg)	590	560	520	560
Silt + Clay (g/kg)	260	300	270	270
Organic carbon (g/kg)	14	13	10	12
pH (20:40 water)	5.8	5.7	5.8	5.8
Exch. Acidity (mg/kg)	33	43	32	36
Exch. Bases (mg/kg)	136	120	103	120

8. Kummannoor, Konni Range, Konni Forest Division. 1910 teak, 60 masl, hilly, pit on midslope, well drained.

00-20 cm Dark reddish brown (5 YR 3/3), gravelly sandy loam, granular, friable, abundant roots, strongly acid.

20-40 Yellowish red (5 YR 4/6), gravelly clay loam, granular, firm, plentiful roots, strongly acid.

40-60 Dark red (2.5 YR 3/6), gravelly clay loam, blocky, very firm, few roots, strongly acid.

	00-20	20-40	40-60	00-60
Gravel (g/kg)	270	330	430	340
Sand (g/kg)	550	440	380	460
Silt + Clay (g/kg)	180	230	190	200
Organic carbon (g/kg)	14	7	4	8
pH (20:40 water)	5.3	5.2	5.4	5.3
Exch. Acidity (mg/kg)	80	49	32	54
Exch. Bases (mg/kg)	77	52	39	56

9. Adichanpara, Konni Range, Konni Forest Division. 1976 teak, 60 masl, hilly, pit on midslope, well drained.

00-20 cm Dark brown-dark reddish brown (7.5 YR 3/4-5 YR 3/4), gravelly loam, granular, friable, abundant roots, medium acid.

20-40 Dark reddish brown-yellowish red (5 YR 3/4-4/6), gravelly clay loam, blocky, few roots, strongly acid.

40-60 Red (2.5 YR 4/6), very gravelly sandy loam, massive, very firm, no roots, medium acid.

	00-20	20-40	40-60	00-60
Gravel (g/kg)	320	370	500	400
Sand (g/kg)	500	410	360	420
Silt + Clay (g/kg)	180	220	140	180
Organic carbon (g/kg)	11	6	2	6
pH (20:40 water)	5.6	5.5	5.6	5.6
Exch. Acidity (mg/kg)	38	32	19	30
Exch. Bases (mg/kg)	76	54	29	53

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10. Uliyanad, Naduvathumoozhi Range, Konni Forest Division. 1914 teak, 50 masl,l hilly, pit on lower slope, well drained.

00-20 cm Dark brown (10 YR 4/3-7.5 YR 4/4), gravelly sandy loam, friable, abundant roots, strongly acid.

20-40 Reddish brown (5 YR 4/4), gravelly loam, blocky, firm, few roots, medium acid.

40-60 Yellowish red (5 YR 4/6), gravelly clay loam, blocky, firm, no roots, medium acid.

	00-20	20-40	40-60	00-60
Gravel (g/kg)	250	240	270	250
Sand (g/kg)	580	550	500	550
Silt + Clay (g/kg)	170	210	230	200
Organic carbon (g/kg)	9	6	4	6
pH (20:40 water)	5.5	5.7	5.9	5.7
Exch. Acidity (mg/kg)	30	30	36	32
Exch. Bases (mg/kg)	79	71	51	67

11. Ulliyanad, Naduvathumoozhi Range, Konni Forest Division. 1971 teak (II), 50 masl, hilly, pit on midslope, well drained.

00-20 cm — Dark brown (7.5 YR-4/4-3/4), sandy loam, granular, firm, plentiful roots, medium acid.

20-40 — Yellowish red (5 YR 4/6), gravelly loam, blocky, firm, few roots, medium acid.

40-60 — Reddish brown (5 YR 4/4), gravelly sandy clay loam, blocky, very firm, no roots, medium acid.

	00-20	20-40	40-60	00-60
Gravel (g/kg)	190	330	250	260
Sand (g/kg)	620	490	540	550
Silt + Clay (g/kg)	190	180	210	190
Organic carbon (g/kg)	9	4	3	5
pH (20:40 water)	5.8	6.0	5.8	5.9
Exch. Acidity (mg/kg)	37	31	30	33
Exch. Bases (mg/kg)	75	53	45	58

12. Pichandikkulam, Naduvathumoozhi Range, Konni Forest Division. 1964 teak, 50 masl, hilly, pit on lower slope, well drained.

00-20 cm — Dark yellowish brown-dark brown (10 YR 3/4-3/3), gravelly sandy loam, granular, firm, plentiful roots, strongly acid.

20-40 — Dark brown (7.5 YR3/4), gravelly clay loam, blocky, very firm, few roots, strongly acid.

40-60 — Yellowish red (5 YR 4/6), gravelly clay loam, massive, very firm, no roots, strongly acid.

	00-20	20-40	40-60	00-60
Gravel (g/kg)	280	370	410	350
Sand (g/kg)	530	420	380	450
Silt + Clay (g/kg)	190	210	210	200
Organic carbon (g/kg)	13	8	4	8
pH (20:40 water)	5.4	5.3	5.5	5.4
Exch. Acidity (mg/kg)	62	40	30	44
Exch. Bases (mg/kg)	42	22	22	29

13. Pothupara, Naduvathumoozhi Range, Konni Forest Division. 1962 teak. 75 masl, hilly, pit on midslope, well drained.

00-20 cm Dark yellowish brown-dark brown (10 YR 3/4-7.5 YR 4/4), gravelly loam, granular, firm, few roots, strongly acid.

20-40 Reddish brown-strong brown (5 YR 4/4-7.5 YR 5/6), gravelly loam. blocky, firm, no roots, medium acid.

40-60 Reddish yellow (7.5 YR 6/6), gravelly sandy loam, massive, very firm, no roots, medium acid.

	00-20	20-40	40-60	00-60
Gravel (g/kg)	280	270	430	330
Sand (g/kg)	520	520	460	500
Silt + Clay (g/kg)	200	210	110	170
Organic carbon (g/kg)	12	6	2	7
PH (20:40 water)	5.4	5.6	5.8	5.6
Exch. Acidity (mg/kg)	49	38	19	35
Exch. Bases (mg/kg)	43	33	20	32

14. Adukeera, Naduvathumoozhi Range, Konni Forest Division. 1937 teak plantation, 50 masl, hilly, pit on midslope, well drained.

00-20 cm Dark brown (10 YR 3/3-7.5 YR 3/4), gravelly clay loam, granular, friable, abundant roots, strongly acid.

20-40 Dar brown (7.5 YR 3/4), gravelly clay loam, blocky, firm, plentiful roots, strongly acid.

40-60 Strong (7.5 YR 4/6), gravelly clay loam, blocky, very firm, few roots, strongly acid.

	00-20	20-40	40-60	00-60
Gravel (g/kg)	310	290	430	340
Sand (g/kg)	460	450	360	430
Silt + Clay (g/kg)	230	260	210	230
Organic carbon (g/kg)	11	9	6	9
pH (20:40 water)	5.3	5.4	5.5	5.4
Exch. Acidity (mg/kg)	67	65	42	58
Exch. Bases (mg/kg)	53	48	38	46

15. Kaikunnam, Mannarappara Range, Konni Forest Division. 1963 teak, 50 masl, hilly, pit on midslope, well drained.

00-20cm Dark brown-dark yellowish brown (10 YR 3/3-3/4), gravelly loam, granular, friable-firm, plentiful roots, strongly acid.

20-40 Dark brown (7.5 YR 4/4), very gravelly clay loam, blocky, firm, few roots, strongly acid.

40-60 Strong brown (7.5 YR 4/6), gravelly clay loam, blocky, very firm, very few roots, very strongly acid.

	00-20	20-40	40-60	00-60
Gravel (g/kg)	400	550	400	450
Sand (g/kg)	420	290	390	370
Silt + Clay (g/kg)	180	160	210	180
Organic carbon (g/kg)	8	4	5	6
pH (20:40 water)	5.2	5.1	5.0	5.1
Exch. Acidity (mg/kg)	42	31	37	37
Exch. Bases (mg/kg)	33	28	28	30

16. Anchukal (Kummannur), Konni Range, Konni Forest Division. Moist deciduous forest, undisturbed, hilly, pit on upper slope, well drained.

00-20 cm Reddish brown (5 YR 4/3), sandy loam, granular, friable, abundant roots, medium acid.

20-40 Red (2.5 YR 4/6), clay loam, granular, friable firm, abundant roots, strongly acid.

40-60 Red (2.5 YR 4/6), loam, massive, firm, few roots, strongly acid.

	00-20	20-40	40-60	00-60
Gravel (g/kg)	*	*	*	*
Sand (g/kg)	750	670	710	710
Silt + Clay (g/kg)	250	330	290	290
Organic carbon (g/kg)	24	12	4	13
pH (20:40 water)	5.6	5.4	5.3	5.4
Exch. Acidity (mg/kg)	86	64	41	64
Exch. Bases (mg/kg)	129	108	100	112

* Uncorrected for gravel

17. Anchukal (Kumnannur), Konni Range, Konni Forest Division. 1910 teak, hilly, pit on midslope, well drained.

00-20 cm Reddish brown (5 YR 4/4), sandy loam, granular, friable, abundant roots, medium acid.

20-40 Red (2.5 YR 4/6), loam, granular-massive, friable-firm, abundant roots, strongly acid.

40-60 Red (2.5 YR 4/6), loam massive, firm, plentiful roots, strongly acid.

	00-20	20-40	40-60	00-60
Gravel (g/kg)	*	*	*	*
Sand (g/kg)	770	730	690	730
Silt + Clay (g/kg)	230	270	310	270
Organic carbon (g/kg)	23	16	8	16
pH (20:40 water)	5.9.	5.5	5.2	5.5
Exch. Acidity (mg/kg)	66	63	61	63
Exch. Bases (mg/kg)	144	122	96	121

* Uncorrected for gravel

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18. Pothupara, Konni Range, Konni Forest Division. 1947 teak (II), level-undulating, pit on level, well drained.

00-20 cm Reddish brown (5 YR 4/3), loam, granular, friable, plentiful roots, strongly acid.

20-40 Reddish brown (5 YR 5/4), clay loam, granular massive, firm, few roots, strongly acid.

40-60 Reddish brown (5 YR 5/4), clay loam, massive, firm, few roots, strongly acid.

	00-20	20-40	40-60	00-60
Gravel (g/kg)	*	*	*	*
Sand (g/kg)	730	660	650	680
Silt + Clay (g/kg)	270	340	350	320
Organic carbon (g/kg)	16	10	8	11
pH (20:40 water)	5.4	5.3	5.2	5.3
Exch. Acidity (mg/kg)	67	57	53	59
Exch. Bases (mg/kg)	116	107	104	109

* Uncorrected for gravel

19. Kokkathode, Naduvathumoozhi Range, Konni Forest Division. Moist deciduous forest, undisturbed, level-undulating, pit on level, well drained.

00-20 cm Reddish brown (5 YR 4/3), loam, granular, friable, abundant roots, strongly acid.

20-40 Red (2.5 YR 4/6), clay loam, granular-massive, friable-firm, plentiful roots, strongly acid.

40-60 Red (2.5 YR 4/6), clay loam, massive, firm, plentiful roots, strongly acid.

	00-20	20-40	40-60	00-60
Gravel (g/kg)	*	*	*	*
Sand (g/kg)	710	680	640	680
Silt + Clay (g/kg)	290	320	360	320
Organic carbon (g/kg)	14	10	5	10
pH (20:40 water)	5.4	5.3	5.2	5.3
Exch. Acidity (mg/kg)	68	60	51	60
Exch. Bases (mg/kg)	128	120	112	120

* Uncorrected for gravel

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20. Kokkathode, Naduvathumoozhi Range, Konni Forest Division. 1937 teak (II), level-undulating, pit on level, well drained.

00-20 cm Dark brown (10 YR 3/3), loam, granular, friable, abundant roots, medium acid.

20-40 Dark brown (10 YR 3/3), loam, granular, friable, abundant roots, medium acid.

40-80 Red (2.5 YR 4/6), clay loam, massive, firm, plentiful roots, strongly acid.

	00-20	20-40	40-60	00-60
Gravel (g/kg)	*	*	*	*
Sand (g/kg)	730	710	640	690
Silt + Clay (g/kg)	270	290	360	310
Organic carbon (g/kg)	17	15	8	13
pH (20:40 water)	5.7	5.7	5.5	5.6
Exch. Acidity (mg/kg)	63	59	48	57
Exch. Bases (mg/kg)	136	129	108	124

* Uncorrected for gravel

DISTRICT : IDUKKY
DIVISION : KOTTAYAM

21. Kodamurutty, Nagarampara Range, Kottayam Forest Division. Semi evergreen forest, undisturbed, 875 masl, hilly, pit on midslope, poorly drained.

00-20 cm Dark yellowish brown (10 YR 3/6), gravelly sandy loam, granular, friable, abundant roots, very strongly acid.

20-40 Yellowish red (5 YR 4/6), gravelly sandy loam, blocky, slightly firm, plentiful roots, very strongly acid.

40-60 Dark red (2.5 YR 3/6), gravelly sandy loam, blocky, slightly firm, plentiful roots, very strongly acid.

	00-20	20-40	40-60	00-60
Gravel (g/kg)	200	270	240	240
Sand (g/kg)	650	560	590	600
Silt + Clay (g/kg)	150	170	170	160
Organic carbon (g/kg)	22	12	10	15
pH (20:40 water)	5.0	4.8	4.8	4.9
Exch. Acidity (mg/kg)	73	57	55	62
Exch. Bases (mg/kg)	64	49	43	52

22. Anchammile, Nagarampara Range, Kottayam Forest Division. Moist deciduous forest, undisturbed, 850 masl, hilly, pit on midslope, poorly drained.

00-20 cm Dark yellowish brown (10 YR 3/6), sandy loam, friable, abundant roots, strongly acid.

20-40 Strong brown (7.5 YR 5/6), gravelly sandy loam, blocky, slightly firm, plentiful roots, strongly acid.

40-60 Reddish brown (5 YR 5/4), gravelly sandy loam, massive, slightly firm, plentiful roots, strongly acid.

	00-20	20-40	40-60	00-60
Gravel (g/kg)	160	260	230	220
Sand (g/kg)	680	580	590	610
Silt + Clay (g/kg)	160	160	180	170
Organic carbon (g/kg)	16	9	8	11
pH (20:40 water)	5.3	5.3	5.2	5.3
Exch. Acidity (mg/kg)	61	44	41	49
Exch. Bases (mg/kg)	53	47	38	46

23. Kodamurutty, Nagarampara Range, Kottayam Forest Division. Grassland, undisturbed, 950 masl, hilly, pit on midslope, moderately well drained.

00-20 cm Dark brown (10 YR 3/3), gravelly loamy sand, granular, very firm, abundant roots, strongly acid.

20-40 Dark reddish brown (2.5 YR 3/4), very gravelly loamy sand, granular, very firm, abundant roots, strongly acid.

40-60 Yellowish red (5 YR 5/8), gravelly sandy loam, blocky, very firm, plentiful roots, strongly acid.

	00-20	20-40	40-60	00-60
Gravel (g/kg)	340	520	410	420
Sand (g/kg)	570	390	450	470
Silt + Clay (g/kg)	90	90	140	110
Organic carbon (g/kg)	18	8	7	11
pH (20:40 water)	5.2	5.2	5.3	5.2
Exch. Acidity (mg/kg)	55	29	31	38
Exch. Bases (mg/kg)	55	25	27	36

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24. Cheruthoni, Nagarampara Range, Kottayam Forest Division. 1977 *Eucalyptus grandis*. 850 masl, hilly, pit on midslope, moderately well drained.

00-20 cm Dark yellowish brown (10 YR 3/6), loamy sand, granular, friable, abundant roots, strongly acid.

20-40 Yellowish red (5 YR 4/6), loamy sand, blocky, slightly firm, plentiful roots, strongly acid.

40-60 Red (2.5 YR 4/6), sandy loam, blocky, firm, few roots, strongly acid.

	00-20	20-40	40-60	00-60
Gravel (g/kg)	190	180	180	180
Sand (g/kg)	690	680	660	680
Silt + Clay (g/kg)	120	140	160	140
Organic carbon (g/kg)	16	13	14	14
pH (20:40 water)	5.2	5.1	5.2	5.2
Exch. Acidity (mg/kg)	71	64	62	66
Exch. Bases (mg/kg)	49	60	49	53

DISTRICT : ERNAKULAM
DIVISION : KOTHAMANGALAM

25. Malayinchi, Thodupuzha Range, Kothamangalam Forest Division. 1961 teak, 650 masl, hilly, pit on midslope, well drained.

00-20 cm Dark brown (10 YR 3/3), gravelly loamy sand, granular friable, abundant roots, medium acid.

20-40 Strong brown (7.5 YR 4/6), gravelly sandy loam, blocky, slightly firm, abundant roots, strongly acid.

40-60 Yellowish red (5 YR 5/8), gravelly sandy loam, blocky, firm, plentiful roots, strongly acid.

	00-20	20-40	40-60	00-60
Gravel (g/kg)	360	310	350	340
Sand (g/kg)	530	550	510	530
Silt + Clay (g/kg)	110	140	140	130
Organic carbon (g/kg)	11	8	6	8
pH (20:40 water)	5.6	5.4	5.3	5.4
Exch. Acidity (mg/kg)	41	40	33	38
Exch. Bases (mg/kg)	66	60	67	64

DISTRICT : IDUKKI
DIVISION : MUNNAR

26. Vattavada, Marayoor Range, Munnar Forest Division. 1958 *Eucalyptus globulus* coppiced in 1969, 1750 masl, hilly, well drained.

00-20 cm Black (5 YR 2.5/1), loamy sand, granular, friable, abundant roots, strongly acid.

20-40 Reddish brown (5 YR 5/4), loam, granular, friable, plentiful roots, very strongly acid.

40-60 Yellowish red (5 YR 4/6), clay, massive, slightly firm, plentiful roots, extremely acid.

	00-20	20-40	40-60	00-60
Gravel (g/kg)	*	*	*	*
Sand (g/kg)	690	620	590	630
Silt + Clay (g/kg)	310	380	410	370
Organic carbon (g/kg)	24	10	9	14
pH (20:40 water)	5.4	4.7	4.4	4.8
Exch. Acidity (mg/kg)	77	60	66	68
Exch. Bases (mg/kg)	198	102	92	131

* Uncorrected for gravel

27. Kanthallur, Marayoor Range, Munnar Forest Division. 1965 *Eucalyptus globulus*, coppiced in 1975, 2300 masl, hilly, well drained.

00-20 cm Black (5 YR 2.5/1), granular, friable, abundant roots, extremely acid.

20-40 Dark reddish brown (5 YR 2.5/2), loamy sand, granular, abundant roots, extremely acid.

40-60 Yellowish red (5 YR 5/8), loam, massive, firm, few roots, very strongly acid.

	00-20	20-40	40-60	00-60
Gravel (g/kg)	*	*	*	*
Sand (g/kg)	ND	830	770	800
Silt + Clay (g/kg)	ND	170	230	200
Organic carbon (g/kg)	50	47	31	43
pH (20:40 water)	4.4	4.5	4.7	4.5
Exch. Acidity (mg/kg)	178	127	79	128
Exch. Bases (mg/kg)	168	120	116	135

* Uncorrected for gravel

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28. Vattavada, Marayoor Range, Munnar Forest Division. Grassland, undisturbed, hilly, pit on crest, well drained.

00-20 cm Dark grey (5 YR 4/1), loam, granular, friable, abundant roots, strongly acid.

20-40 Reddish brown (5 YR 4/3), clay loam, granular, friable, plentiful roots, very strongly acid.

40-60 Reddish brown (5 YR 5/3), clay, massive, few roots, extremely acid.

	00-20	20-40	40-60	00-60
Gravel (g/kg)	*	*	*	*
Sand (g/kg)	720	650	540	640
Silt + Clay (g/kg)	280	350	460	360
Organic carbon (g/kg)	5	11	11	9
pH (20:40 water)	5.3	4.6	4.4	4.8
Exch. Acidity (mg/kg)	87	51	91	76
Exch. Bases (mg/kg)	184	116	160	153

* Uncorrected for gravel

DISTRICT : ERNAKULAM
DIVISION : MALAYATTOOR

29. Pothupara, Thundathil Range, Malayattoor Forest Division. 1971 teak, 70 masl, rolling, pit on upper slope, well drained, plentiful undergrowth. Plot 1 of 500 m transect.

00-20 cm Dark brown (10 YR 3/3), gravelly sandy loam, granular, friable, abundant roots, medium acid.

20-40 Dark yellowish brown (10 YR 3/4), gravelly loam, granular, friable, plentiful roots, medium acid.

40-60 Dark brown (7.5 YR 3/4), gravelly loam, massive, slightly firm, few roots, medium acid.

	00-20	20-40	40-60	00-60
Gravel (g/kg)	440	380	470	430
Sand (g/kg)	430	440	360	410
Silt + Clay (g/kg)	130	180	170	160
Organic carbon (g/kg)	9	8	5	7
pH (20:40 water)	5.9	5.9	5.8	5.9
Exch. Acidity (mg/kg)	21	22	15	19
Exch. Bases (mg/kg)	62	68	53	61

30. Pothupara, Thundathil Range, Malayattoor Forest Division. 1971 teak, 50 masl, rolling, pit on midslope, well drained, plentiful undergrowth. Plot 2 of 500 m transect.

00-20 cm Dark reddish brown (5 YR 3/3), loamy sand, granular, friable, abundant roots, medium acid.

20-40 Dark reddish brown (5 YR 3/4), gravelly sandy loam, granular, slightly firm, plentiful roots, medium acid.

40-60 Reddish brown (5 YR 4/4), gravelly sandy loam, massive, very firm, very few roots, medium acid.

	00-20	20-40	40-60	00-60
Gravel (g/kg)	110	320	350	260
Sand (g/kg)	700	520	500	570
Silt + Clay (g/kg)	190	160	150	170
Organic carbon (g/kg)	18	10	8	12
pH (20:40 water)	5.8	5.7	5.6	5.7
Exch. Acidity (mg/kg)	44	32	29	35
Exch. Bases (mg/kg)	89	68	52	70

31. Pothupara, Thundathil Range, Malayattoor Forest Division. 1971 teak, 60 masl, rolling, pit on midslope, well drained, plentiful undergrowth. Plot 3 of 500 m transect.

00-20 cm Dark reddish brown (5 YR 3/3), gravelly sandy loam, granular, friable, abundant roots, medium acid.

20-40 Dark reddish brown (5 YR 3/4), gravelly loam, granular-massive, slightly firm, plentiful roots, strongly acid.

40-60 Yellowish red (5 YR 4/6), gravelly loam, massive, firm, no roots, strongly acid.

	00-20	20-40	40-60	00-60
Gravel (g/kg)	300	400	420	370
Sand (g/kg)	530	440	430	470
Silt + Clay (g/kg)	170	160	150	160
Organic carbon (g/kg)	12	6	4	7
pH (20:40 water)	5.7	5.4	5.4	5.5
Exch. Acidity (mg/kg)	36	27	20	28
Exch. Bases (mg/kg)	70	48	46	55

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32. Pothupara, Thundathil Range, Malayattoor Forest Division. 1971 teak, 90 masl, hilly, pit on upper slope, well drained, plentiful undergrowth. Plot 4 of 500 m transect.

00-20 cm Dark reddish brown (5 YR 3/3), gravelly sandy loam, granular, friable, abundant roots, medium acid.

20-40 Dark reddish brown (5 YR 3/4), gravelly loam, granular-massive, firm, plentiful roots, strongly acid.

40-60 Reddish brown (5 YR 4/4), very gravelly loam, massive, firm, no roots, strongly acid.

	00-20	20-40	40-60	00-60
Gravel (g/kg)	310	390	500	400
Sand (g/kg)	550	440	340	440
Silt + Clay (g/kg)	140	170	160	160
Organic carbon (g/kg)	12	9	6	9
pH (20:40 water)	5.6	5.5	5.4	5.5
Exch. Acidity (mg/kg)	31	29	20	27
Exch. Bases (mg/kg)	69	61	45	58

33. Pothupara, Thundathil Range, Malayattoor Forest Division. 1971 teak, 30 masl, rolling, pit on lower slope, well drained, plentiful undergrowth. Plot 5 of 500 m transcet.

00-20 cm Dark brown-brown (7.5 YR 4/4), gravelly loam, granular, friable, abundant roots, strongly acid.

20-40 Reddish brown (5 YR 4/4), very gravelly clay loam, massive, firm, very few roots, strongly acid.

40-60 Yellowish red (5 YR 5/6), very gravelly clay loam, massive, very firm, no roots, strongly acid.

	00-20	20-40	40-60	00-60
Gravel (g/kg)	330	560	530	480
Sand (g/kg)	480	290	310	360
Silt + Clay (g/kg)	190	150	160	160
Organic carbon (g/kg)	10	4	2	5
pH (20:40 water)	5.3	5.3	5.4	5.3
Exch. Acidity (mg/kg)	27	15	14	19
Exch. Bases (mg/kg)	47	31	33	37

DISTRICT : THRISSUR
DIVISION : VAZHACHAL

34. Kollathirumed, Kollathirumed Range, Vazhachal Forest Division. 1966 eucalypt, 400 masl, hilly, well drained.

00-20 cm Dark reddish brown (5 YR 3/4), loam, granular, friable, plentiful roots, very strongly acid.

20-40 Dark reddish brown (5 YR 3/4), gravelly loam, granular, friable, few roots, extremely acid.

40-60 Yellowish red (5 YR 5/6), gravelly loam, massive, firm, few roots, very strongly acid.

	00-20	20-40	40-60	00-60
Gravel (g/kg)	*	*	*	*
Sand (g/kg)	690	660	640	660
Silt + Clay (g/kg)	310	340	360	340
Organic carbon (g/kg)	24	17	12	18
pH (20:40 water)	4.8	4.5	5.0	4.8
Exch. Acidity (mg/kg)	89	80	61	77
Exch. Bases (mg/kg)	116	125	81	107

* Uncorrected for gravel

35. Vazhachal, Vazhachal Range, Vazhachal Forest Division. Evergreen forest, 400 masl, hilly, well drained.

00-20 cm Reddish brown (5 YR 4/3), loamy sand, granular, friable, abundant roots, strongly acid.

20-40 Yellowish red (5YR 4/6), loam granular, friable, plentiful roots, strongly acid.

40-60 Yellowish red (5 YR 4/6), gravelly loam, massive firm, few roots, strongly acid.

	00-20	20-40	40-60	00-60
Gravel (g/kg)	*	*	*	*
Sand (g/kg)	800	750	740	760
Silt + Clay (g/kg)	200	250	260	240
Organic carbon (g/kg)	13	8	7	9
pH (20:40 water)	5.4	5.5	5.5	5.5
Exch. Acidity (mg/kg)	39	34	37	37
Exch. Bases (mg/kg)	67	73	74	71

* Uncorrected for gravel

Checklist of Mammals in the region

Sl. No.	Common name	Status	Species name	Remarks
1.	Madras Hedgehog	--	*Hemiechinus nudiventris* (Horsfield, 1851)	Endemic to Western Ghats
2.	Kelaart's Long-clawed Shrew	VU	*Feroculus feroculus* (Kelaart, 1850)	Eravikulam National Park and Nilgiri Hills
3.	Day's Shrew	VU	*Suncus dayi* (Dobson, 1888)	Endemic to Western Ghats
4.	House (Grey musk) Shrew, Musk rat	LRlc	*Suncus murinus* (Linnaeus, 1766)	Throughout India
5.	South Indian (Madras) Tree shrew	LRnt	*Anathana ellioti* (Waterhouse, 1850)	Endemic to India; Periyar in Wyanad WLS.
6.	Short-nosed Fruit Bat	LRlc	*Cynopterus sphinx* (Vahl, 1797)	Throughout India
7.	Salim Ali's Fruit Bat	EN	*Latidens salimalii* (Thonglongya, 1972)	Endemic to Western Ghats; Agasthyamalai Hills
8.	Indian Flying Fox	LRnt	*Pteropus giganteus* (Brunnich, 1782)	Throughout India
9.	Fulvous (Rousette) Fruit Bat	LRlc	*Rousettus leschenaulti* (Desmarest, 1820)	Throughout India
10.	Dawn (Cave Fruit) Bat, Dobson's Long-tongued Fruit Bat	--	*Eonycteris spelaea* (Dobson, 1871)	South West India
11.	Lesser Mouse-tailed (Lesser Rat-tailed) Bat	LRnt	*Rhinopoma hardwickii* (Gray, 1831)	All over India
12.	Pouch-bearing Bat	DD	*Saccolaimus saccolaimus* (Temminck, 1836)	All over India
13.	Long-winged Tomb	LRlc	*Taphozous longimanus* (Hardwicke, 1825)	Peninsular India up to Gujarat
14.	Black-bearded Tomb (Bearded Sheath-tails)	LRnt	*Taphozous melanopogon* (Temminc, 1841)	All over India
15.	Naked-rumped Tomb Bat	LRnt	*Taphozous nudiventris* (Cretzschmar, 1830)	All over India
16.	Greater False-vampire Bat	LRlc	*Megaderma lyra* (E. Geoffroy, 1810)	All over India
17.	Lesser False-vampire Bat	DD	*Megaderma spasma* (Linnaeus, 1758)	All over India
18.	Blyth's (Little India) Horse-shoe Bat	LRnt	*Rhinolophus lepidus* (Blyth, 1844)	All over India
19.	Wooly (Great Eastern) Horse-shoe Bat	DD	*Rhinolophus luctus* (Temminck, 1835)	India, except NW India
20.	Fulvus Leaf-nosed Bat	LRnt	*Hipposideros fulvus* (Gray, 1838)	All over India
21.	Cantor's (Fawn) Leaf-nosed Bat	DD	*Hipposideros galeritus* (Cantor, 1846)	All over India
22.	Andersen's Leaf-nosed Bat	DD	*Hipposideros pomona* (K. Andersen, 1918)	South India, Sikkim and Assam
23.	Bellary Leaf-nosed Bat	DD	*Hipposideros schistaceus* (K. Andersen, 1918)	Endemic to South India
24.	Schneider's Leaf-nosed Bat	LRnt	*Hipposideros speoris*	Kerala

			(Schneider, 1800)	
25.	Tickell's Bat	DD	*Hesperoptenus tickelli* (Blyth, 1851)	All over India
26.	Burmese Whiskered Bat	DD	*Myotis montivagus* (Dobson, 1874)	South India
27.	Chocolate Bat	DD	*Pipistrellus affinis* (Dobson, 1871)	All over India
28.	Kelaart's Pipistrelle	LRlc	*Pipistrellus ceylonicus* (Kelaart, 1852)	All over India
29.	India Pipistrelle	LRnt	*Pipistrellus coromandra* (Gray, 1838)	All over India
30.	Dormer's Bat	LRnt	*Pipistrellus dormeri* (Dobson, 1875)	All over India
31.	Least Pipistrelle	LRlc	*Pipistrellus tenuis* (Temminck, 1840)	All over India
32.	Asiatic Greater Yellow House Bat	LRlc	*Scotophilus heathii* (Horsfield, 1831)	All over India
33.	Asiatic Lesser Yellow House Bat	LRnt	*Scotophilus Kuhlii* (Leach, 1821)	All over India
34.	Bamboo (Flat-headed, Club-footed) Bat	?	*Tylonycteris pachypus* (Temminck, 1840)	N,S, and E India
35.	Nicobar Long-fingerd Bat	DD	*Miniopterus pusillus* (Dobson, 1876)	South India
36.	Schreibers'Long-fingered (Common Bent-wing) Bat	LRlc	*Miniopterus schreibersi* (Kuhl, 1817)	All over India
37.	Hairy-winged Bat	DD	*Harpiocephalus harpia* (Gray, 1842)	Kerala
38.	Round-eared Tube-nosed Bat	DD	*Murina cyclotis* (Dobson, 1972)	South India
39.	Hardwicke's Forest Bat	DD	*Kerivoula hardwickii* (Horsfield, 1824)	Throughout India
40.	Painted Bat	LRnt	*Kerivoula picta* (Pallas, 1767)	Throughout India
41.	Winkle-lipped Free-tailed Bat	DD	*Chaerephon plicata* (Buchanan, 1800)	Throughout India
42.	Wroughton's free tailed bat	CR	*Otomops wroughtoni* (Thomas, 1913)	Endemic to Western Ghats
43.	Egyptian Free-tailed Bat	LRnt	*Tadarida aegyptiaca* (E. Geoffroy, 1818)	Throughout India
44.	Slender Loris	--	*Loris tardigradus* (Linnaeus, 1758)	Kerala, Tamilnadu, etc.
45.	Bonnet Macaque	LRlc	*Macaca radiata* (E. Geoffroy, 1812)	India
46.	Lion-tailed Macaque	EN	Macaca silenus (Linnaeus, 1758)	Western Ghats
47.	Common Langur	LRlc	*Semnopithecus entellus* (Dufresne, 1797)	Throughout India
48.	Nilgiri langur, Hooded leaf monkey	VU	*Trachypithecus johnii* (J. Fischer, 1829)	Western Ghats in Kerala
49.	Golden Jackal	LRlc	*Canis aureus* (Linnaeus, 1758)	Throughout India
50.	Domestic Dog	--	*Canis familiaris* (Linnaeus, 1758)	
51.	Bengal (India) Fox	LRnt	*Vulpes bengalensis* (Shaw, 1800)	Throughout India
52.	Sloth Bear	VU	*Melursus ursinus* (Shaw, 1791)	Allover India
53.	Nilgiri Marten	VU	*Martes gwatkinsi* (Horsfield, 1851)	Endemic to Western Ghats Eravikulam National Park

54.	Common Otter	--	*Lutra lutra* (Linnaeus, 1758)	South India
55.	Malabar Civet	CR	*Viverra civettina* (Blyth, 1962)	Western Ghats
56.	Small Indian Civet	LRnt	*Viverricula indica* (Desmarest, 1804)	Throughout India
57.	Common palm civet, Toddy Cat	LRlc	*Paradoxurus hermaphroditus* (Pallas, 1777)	Throughout India
58.	Brown Palm Civet, Coffee Civet	VU	*Paradoxurus jerdoni* Blanford, (1885)	Western Ghats
59.	Brown mongoose	--	*Herpestes brachyurus* (Gray, 1837)	Agasthyamalai regions
60.	Grey mongoose	LRlc	*Herpestes edwardsii* (E. Geoffroy Saint-Hilaire, 1818)	
61.	Stripe-necked mongoose	LRnt	*Herpestes vitticollis* (Bennett, 1835)	Western Ghats; PTR
62.	Striped Hyaena	LRnt	*Hyaena hyaena* (Linnaeus, 1758)	Throughout India
63.	Jungle Cat	LRnt	*Felis chaus Schreber*, (1777)	Throughout India
64.	Leopard Cat	LRnt	*Prionailurus bengalensis* (Kerr, 1792)	Silent valley National Park
65.	Rusty-spotted cat	LRnt	*Prionailurus rubiginosus* (I. Geoffroy Saint-Hilaire, 1831)	Peninsular India
66.	Fishing cat	VU	*Prionailurus viverrinus* (Bennett, 1833)	Throughout India
67.	Leopard	VU	*Panthera pardus* (Linnaeus, 1758)	Throughout India
68.	Tiger	EN	*Panthera tigris* (Linnaeus, 1758)	All over India (Except J and K)
69.	Common Dolphin	LRnt	*Delphinus delphis* (Linnaeus, 1758)	Travancore Coast
70.	Pigmy Killer Whale, Slender Blackfish	--	*Feresa attenuata* (Gray, 1875)	World wide
71.	Short-finned Pilot Whale	LRnt	*Globicephala macrorhynchus* (Gray, 1846)	World wide
72.	Grey Dolphin	LRnt	*Grampus griseus* (G. Cuvier, 1812)	World wide
73.	Fraser's Dolphin	--	*Lagenodelphis hosei* (Fraser, 1957)	Within Indian ocean
74.	Irrawaddy Dolphin	EN	*Orcaella brevirostris* (Gray, 1866)	?
75.	Killer Whale	LRnt	*Orcinus orca* (Linnaeus, 1758)	World wide
76.	False Killer Whale	LRnt	*Pseudorca crassidens* (Owen, 1846)	World wide
77.	Indo-Pacific hump-back Dolphin	EN	*Sousa chinensis* (Osbeck, 1765)	Throughout the world
78.	Pantropical spotted dolphin	--	*Stenella attenuata* (Gray, 1846)	World wide
79.	Spinner Dolphin	LRnt	*Stenella longirostris* (Gray, 1828)	World wide
80.	Bottle-nosed Dolphin	LRnt	*Tursiops truncatus* (Montagu, 1821)	World wide
81.	Finless porpoise	LRnt	*Neophocaena phocaenoides* (G. Cuvier, 1829)	Kerala coasts
82.	Pygmy Sperm Whale	LRnt	*Kogia breviceps* (Blainville, 1838)	Throughout tropical subtropical oceans
83.	Sperm Whale (Cachalot)	LRnt	*Physeter catodon* (Linnaeus, 1758)	Throughout Indian Ocean
84.	Ginkgo-toothed Beaked Whale	--	*Mesoplodon ginkgodens*(Nishiwaki and Kamiya, 1958)	Indian ocean
85.	Sei Whale	LRnt	*Balaenoptera borealis* (Lesson,	Worldwide in temperate

			1828)	and subtropical waters
86.	Bryde's Whale	LRnt	*Balaenoptera edeni* (Anderson, 1879)	Worldwide in tropical and subtropical waters
87.	Blue whale	CR	*Balaenoptera musculus* (Linnaeus, 1758)	World wide
88.	Fin Whale	LRnt	*Balaenoptera physalus* (Linnaeus, 1758)	World wide
89.	Indian Chevrotin, Mouse Deer	LRnt	*Moschiola meminna* (Erxleben, 1777)	Peninsular India
90.	Wild Boar	LRlc	*Sus scrofa* (Linnaeus, 1758)	Throughout India
91.	Spotted Deer	LRlc	*Axis axis* (Erxleben, 1777)	Throughout India
92.	Sambar	LRlc	*Cervus unicolor* (Kerr, 1792)	Throughout India
93.	Indian Muntjac, Barking Deer, Rib-faced Deer	LRlc	*Muntiacus muntjak* (Zimmemann, 1780)	Throughout India
94.	Gaur, Indian Bison	VU	*Bos gaurus* (Smith, 1827)	Western Ghats
95.	Nilgiri Tahr	EN	*Hemitragus hylocrius* (Ogilby, 1838)	Western Ghats
96.	Indian Pangolin	LRnt	*Manis crassicaudata* (Gray, 1827)	Throughout India
97.	Layard's Striped Squirrel	DD	*Funambulus layardi* (Blyth, 1849)	Western Ghats (?)
98.	Indian Palm Squirrel	LRlc	*Funambulus palmarum* (Linnaeus, 1766)	Peninsular India
99.	Dusky Striped Squirrel	DD	*Funambulus sublineatus* (Waterhouse, 1838)	Western Ghats from Coorg, South wards
100.	Jungle striped squirrel	LRnt	*Funambulus tristriatus* (Waterhouse, 1837)	Endemic to Western Ghats
101.	Indian Giant Squirrel	VU	*Ratufa indica* (Erxleben, 1777)	Peninsular India
102.	Elliot's Giant (Large) Flying Squirrel	LRnt	*Petaurista philippensis* (Elliot, 1839)	Kerala
103.	Travancore Flying Squirrel	VU	*Petinomys fuscocapillus* (Jerdon, 1847)	Western Ghats
104.	Lesser Bandicoot-rat	LRlc	*Bandicota bengalensis* (Gray and Hardwicke, 1833)	Throughout India
105.	Bandicota indica	LRnt	*Bandicota indica* (Bechstein, 1800)	Throughout India
106.	Indian Bush Rat	LRlc	*Golunda ellioti* (Gray, 1837)	Throughout peninsular India
107.	Soft-furred field rat	LRlc	*Millardia meltada* (Gray, 1837)	
108.	Little Indian Field Mouse	LRlc	*Mus booduga* (Gray, 1837)	Throughout India
109.	Cook's Mouse	LRnt	*Mus cookii* (Ryley, 1914)	Western Ghats
110.	Bonhote's Mouse	EN	*Mus famulus* (Bonhote, 1898)	Endemic to Western Ghats
111.	House mouse	LRlc	*Mus musculus* (Linnaeus, 1758)	Indoor forms throughout India
112.	Fawn coloured mouse	LRlc	*Mus phillipsi* (Wroughton, 1912)	Peninsular India
113.	Spiny field mouse	LRlc	*Mus platythrix* (Bennett, 1832)	Peninsular India
114.	Elliot's Brown Spiny mouse	LRlc	*Mus saxicola* (Elliot, 1839)	Kerala
115.	Ranjini's Rat	VU	*Rattus ranjiniae* (Agarwal and Ghosal, 1959)	Endemic to Western Ghats
116.	Malabar Spiny Mouse (Spiny Dormouse)	LRlc	*Platacanthomys lasiurus* (Blyth, 1859)	Endemic Western Ghats

EX – Extinct
CR – Critically Endangered
EN – Endangered
VU – Vulnerable
LRnt – Lower Risk – near threatened
LR1c - Lower Risk-least concerned
DD - Data deficient

Source: Nameer, P.O, 1998. Checklist of Indian Mammals. Kerala Forest Department (Wildlife wing) and Kerala Agricultural University. 90+XXV pp.

Algae Associated with Mangroves

Chlorophyta

1. *Ulva* fasciata
2. *Ulva lactuca*
3. *Ulva reticulata*
4. *Enteromorpha clathrata*
5. *Enteromorpha intestinalis*
6. *Enteromorpha flexusa*
7. *Monostroma* sp.
8. *Cladophora* sp.
9. *Chaetomorpha linum*
10. *Rhizoclorium knereri*
11. *Rhizoclorium riparium*
12. *Codium fragile*
13. *Codium elongatum*
14. *Diohotomosiphon salina*

Phaeophyta

15. *Giffordia mitchellae*
16. *Dictyotta indica*
17. *Padina tetrastoromatica*
18. *Spatoglossum asperum*
18. *Colpomenia sinuosa*
19. *Sargassum* sp.

Rhodophyta

20. *Gracilaria verrucosa*
21. *Hypena musciformis*
22. *Catenalla impudica*
23. *Caloglossa leprieuri*
24. *Polysiphonia macrocarpa*
25. *Polysiphonia ianosa*
26. *Bostrychia tenella*

Cyanophyta

27. *Chlorococcus turgidus*
28. *Aphaniotheca saxicola*
29. *Oscillatoria earlei*
30. *Oscillatoria limosa*
31. *Oscillatoria nigrovirdis*
32. *Oscillatoria annae*
33. *Oscillatoria pinceps*
34. *Oscillatoria marttinii*

35. *Oscillatoria* sp.
36. *Phormidium fragile*
37. *Phormidium* sp.
38. *Spirulina* sp.
39. *Schizothrix* sp.
40. *Macrocoleus echthnoplastes*
41. *Anabaena* sp.
42. *Calothrix crustaceae*

Macro-invertebrate fauna recorded from the Mangroves

Polychaeta

Heteromastus similis
Euclymene annandalei
Perinereis sp.
Mercierella enigmatica

Bivalvia

Dostia (Neritina) credpidularia
Telescopium telescopium
Cerithidea fluviatilis
Cerithidea obtusa
Littorina scarba
Assiminera nitida
Pythia plicata
Melampus ceylonicuss
Cassidual nucleus

Cirripedia

Balanus amphitrite

Tanaidacea

Tanais sp.
Aspseudes gymnophobia
Halmyrapseudes killaiyensis

Isopods

Ligia exotica
Cirolana fluviatilis
Sphaeroma terebrans
Sphaeroma annandalei

Amphipoda

Pavacalliope sp.
Grandidierella sp.
Corophium triacnonyx
Talorchestia sp.
Scylla serrata
Scylla tranguebarica
Thalamita crenata

Phytoplanktons of the fresh waters

Group	**Phyto plankton genera**
Cyanophyceae	Anabaena Microcysts Oscillatoria Synechococcus
Chlorophycae/ Desmidaceae	Pediastrum Ankistrodesmus Chlamydomonas Xanthidium Botryococcs Microspora Chlorella Monostroma Closterium Treubaria Cosmarium Oosystis Scenedesmus Staurastrum Tetraedron Ulothrix
Bacillariophyceae	Amphiphera Asterionella Cyclotella Diatoma Fragillaria Nitzschia Melosira Stephanodiscus Synedra Tabellaria

Pyrrophyta	Pinnularia
	Gaunyaulax
	Peridinium
Chrysophyta	Dinobryon
	Chromulina
	Mallomonas
	Uroglena

Phytoplankton

Major phytoplankton genera observed in the fresh water bodies are Blue green algae, Green algae and Diatoms. The filamentous algae microspora sp. had the maximum density followed by monostroma sp. The blue green algae, especially Anacystus sp., Spirulina sp. are the major constituent of the phytoplankton. The Desmids and Diatoms are comparatively less in the lentic water bodies. Presence of phytoplankton genera like Pediastrum, Staurastrum, Treubaria, Dinobryon, Peridinium, Gonyaulax, Asterionella etc. in some of the water bodies clearly indicates the eutrophic status of the water quality.

Fresh water fishes

Order	Family	Species
Elopiformes	Megalopidae	*Megalopes cyprinoides* (Broussonet)
Anguilliformes	Anguillidae	*Anguilla bengalensis bengalensis* (Gray & Hard wicke)
		Anguilla bicolor bicolor (Mc Clelland)
Clupeiformes	Clupeidae	
	Pellonulinae(S. F.)	*Dayella malabarica* (Day)
	Engranlidae	*Stolephorus commersonii* Lacepede
Cypriniformes	Cyprinidae	
	Cyprininae (S.F)	*Catla catla* (Hamilton)
		Cirrhinus mrigala (Hamilton)
		Cyprinus carpio communis (Linnaeus)
		Crossochilus periyarensis (Menon & Jacob)
		Hypselobarbus curmuca (Hamilton)
		Hypselobarbus kolus (sykes)
		Hypselobarbus thomassi (Day)
		Hypselobarbus jerdoni (Day)
		Hypselobarbus micropogon (Val)
		Hypselobarbus pulchellus (Day)
		Hypselobarbus kurali (Menon & Ramadevi)
		Labeo rohita (Hamilton)
		Labeo calbasu (Hamilton)
		Osteobrama bakeri (Day)
		Osteochilichthys longidorsalis (Pethiyagoda and kottelat)
		Osteochilichthys thomassi (Day)
		Puntius amphibins (Valenciennes)
		Puntius chola (Hamilton)
		Puntius denisonii (Day)
		Puntius dorsalis (Jordon)
		Puntius filementosus (Valenciennes)
		Puntius melonostigma (Day)
		Puntius curmuca (Day)
		Puntius ophiocephalus (Raj)
		Puntius melanampyx (Day)
		Puntius parrah (Day)
		Puntius ticto (Hamilton)
		Puntius vittatus (Day)
		Barbodes carnaticus (Jerdon)
		Barbodes sarana subnasutus (Valenciennes)
		Tor khudree (Sykes)

Order	Family	Species
	Cultrinae (S. F.)	*Salmostoma boopis* (Day)
	Rasborinae (S.F)	*Amblypharyngodon melettinus* (Valenciennes)
		Barilius bakeri (Day)
		Barilius bandelisis (Hamilton)
		Barilius gatensis (Valenciennes)
		Danio aequippinnatus (Mc Clelland)
		Danio malabaricus (Jerdon)
		Esomus danricus (Hamilton)
		Parluciosoma daniconias (Hamilton)
	Garrinae (S. F.)	*Garra lamta* (Hamilton)
		Garra mc Clelland (Jerdon)
		Garra mullya (Syker)
		Garra surendranathanii (Shaji, Arun & Easa)
	Balitoridae	
	Balitorina (S. F.)	*Bhavania australis* (Jerdon)
		Travencoria elongata (Pethiyagoda & Kottelat)
		Travencoria Jonesi (Hora)
	Nemacheilinae(S. F.)	*Nemacheilus guentheri* (Day)
		Nemacheilus triangularis (Day)
		Nemacheilus donisonii (Day)
	Cobitidae	
	Cobitinae (S. F.)	*Lepidocephalus thermalis* (Valenciennes)
Siluriformes	Bagridae	*Horabagrus brachysoma* (Gunther)
		Horabagrus nigricollaris (Pethiyagoda kottelat)
		Pseudobagrus chryseus (Day)
		Mystus gulio (Hamilton)
		Mystus armatus (Jerdon)
		Mystus cavasius (Hamiton)
		Mystus malabaricus (Jerdon)
		Mystus oculatus (Valensiennes)
		Mystus vittatus (Bloch)
	Siluridae	*Ompok bimaculatus* (Bloch)
		Ompok malabaricus (Valenciennes)
		Wallago attu (Schneider)
	Sisoridae	*Glyptothorax lonah* (Sykes)
		Glyptothorax madrasapatanum (Day)

Order	Family	Species
	Claridae	*Clarias butrachus* (Dinnaeus)
	Heteropneustedae	*Heteropneustes fossilis* (Bloch)
	Ariidae	*Arias caelatus* (Valenciennes)
Cyprinodontiformes	Hemiramphidae	*Hyporamphus limbatus* (Valenciennes)
	Belonidae	*Xenentedon cancila* (Hamilton)
	Aplocheilidae	*Aplocheilus lineatus* (Valenciennes)
		Aplocheilus panchax (Hamilton)
Synbranchiformes	Synbranchidae	*Ophisternon bengalense* (Mc Clelland)
Perciformes	Ambassidae	*Parambassis thomassi* (Day)
		Parambassis dayi (Bleeker)
	Terraponidae	*Terapon jarbua* (Forsskal)
	Carangidae	*Caranx carangus* (Bloch)
	Lutjanidae	*Lutjanus argentimaculatus* (Forsskal)
	Gerreidae	*Gerres filementosus* (Cuvier)
	Sciänidae	*Macrospinosa cuja* (Hamilton)
	Scatophagidae	*Scatophagus argus* (linnaeus)
	Nandidae	
	Pristo lepidinae (S.F)	*Pristolepis marginatus* (Jerdon)
	Nandinae (S. F.)	*Nandus nandus* (Hamilton)
	Cichlidae	*Etroplus maculatus* (Bloch)
		Etroplus suratensis (Bloch)
		Oreochromis mossambica (Peters)
	Mugilidae	*Mugil cephalus* (Linnaeus)
	Gobiidae	
	Gobinae(S.F)	*Glossogobius giuris* (Hamilton)
	Anabantidae	*Anabas testudineus* (Bloch)
	Belontidae	
	Macropodinae(S.F)	*Macropodus cupanus* (Valenciennes)
	Channidae	*Channa marulius* (Hamilton Buchanan)
		Channa orientalis (Bloch & Schneider)
		Channa strictus (Block)
		Channa gachua (Ham-Buch)
	Mastacembelidae	*Macrognathus guentheri* (Day)
		Mustacembelus armatus (Lecepede)
Pleuronectiformes	Solteidae	*Euryglossa orientalis* (Bloch & Schneider)
Tetradontiformes	Tetradontidae	*Tetraodon travancoricus* (Hora & Nair)